

THE HOPE REPORTS

VOL. III

1902

THE STRUGGLE FOR EXISTENCE
PROTECTIVE RESEMBLANCE
MIMICRY, WARNING COLOURS
AND SEASONAL CHANGES IN
AFRICAN INSECTS

EDITED BY

EDWARD B. POULTON, M.A., D.Sc.

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'Semper Africa novi aliquid apportat'

OXFORD

PRINTED FOR PRIVATE CIRCULATION

BY HORACE HART, PRINTER TO THE UNIVERSITY

1903



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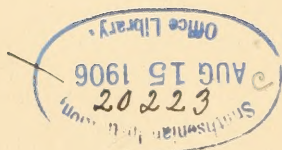
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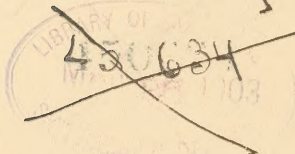
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PREFACE

IT is now ten years since the death of the veteran entomologist—the most distinguished of all students of Insect systematics—who was the first occupant of the Hope Chair of Zoology. At the end of a period which must form a considerable fraction of the active life of any man, it is appropriate that I should lay before the University and those who desire to promote scientific research in our land, a brief statement of the work which has been done and of hopes for the future.

The two main lines of work which are suggested by the presence of the Hope Collection in Oxford, were clearly explained to the electors to the vacant chair by the late Professor Huxley.

‘There are two courses open,’ he wrote, on Jan. 15, 1893, ‘for either of which there is a good deal to be said. It may be considered that the chief business of the Professor is to be an efficient Curator of the great collection of Insects under his charge, to sort it out into so-called species, and catalogue them in such a manner that the Collection may be made as available and useful as possible to systematists and students of Geographical Distribution. . . . The other course is to elect a Professor, . . . who will use the Collection as a means to the elucidation of the larger problems which now press upon us. This is the alternative which would

commend itself to me if I had anything to do with the appointment.'

A very natural inquiry may be raised as to why a collection of *Insects*, above all other animals, should be so especially valuable for the elucidation of the larger problems which deal, not only with the species of a single group, but with every one of the innumerable and infinitely varied forms, vegetable no less than animal, in which life manifests itself. The answer is to be found in the large number of offspring produced by each pair of Insects, and the rapidity with which the generations succeed each other, many cycles being completed in a single year in warm countries; in the severity of the struggle for life which prevents this remarkable rate of multiplication from becoming the cause of any progressive increase in the number of individuals; and finally in the character of the struggle itself, which is precisely of that highly specialized kind between the keen senses and activities of enemies and the means of concealment or other modes of defence of their Insect prey, which leads by action and answering reaction to a progressive raising of the standard in both pursuer and pursued. This is why it is that Insects mean so much to the naturalist or the philosopher who desires to look beneath the surface for the forces which have moulded existing forms of life out of earlier and very different forms. The wings of butterflies, it has been said¹, 'serve as a tablet on which

¹ H. W. Bates, quoted by A. R. Wallace in 'Natural Selection,' London, 1875, p. 132. A more extended quotation is much to the point. H. W. Bates was writing in 'The Naturalist on the Amazons' (London, pp. 347, 348 of the 1879 edition), on the abundance and variety of the butterflies at Ega on the Upper Amazons. (A few of the actual specimens captured by him in this locality are in the Hope Collection.) 'I paid especial attention to them,' he writes, 'having found that this tribe was better adapted than almost any

Nature writes the story of the modifications of species.' But the careful study of Insects tells us even more than this; for it gives us the clearest insight we as yet possess into the forces by which those modifications have been brought about. Light is thrown upon the causes to which organic evolution is due no less than upon the course which organic evolution has pursued.

In issuing the third volume of Hope Reports it may be claimed not unjustly that these insistent 'larger problems' have received during the past ten years that special attention which Huxley advocated. The subject which more than any other has claimed the attention of the Hope

other group of animals or plants, to furnish facts in illustration of the modifications which all species undergo in nature under changed local conditions. This accidental superiority is owing partly to the simplicity and distinctness of the specific characters of the insects, and partly to the facility with which very copious series of specimens can be collected and placed side by side for comparison. The distinctness of the specific characters is due probably to the fact that all the superficial signs of change in the organization are exaggerated and made unusually plain by affecting the framework, shape, and colour of the wings, which, as many anatomists believe, are magnified extensions of the skin around the breathing orifices of the thorax of the insects. These expansions are clothed with minute feathers or scales, coloured in regular patterns, which vary in accordance with the slightest change in the conditions to which the species are exposed. It may be said, therefore, that on these expanded membranes nature writes, as on a tablet, the story of the modifications of species, so truly do all changes of the organization register themselves thereon. Moreover, the same colour-patterns of the wings generally show, with great regularity, the degrees of blood-relationship of the species. As the laws of nature must be the same for all beings, the conclusions furnished by this group of insects must be applicable to the whole organic world; therefore the study of butterflies—creatures selected as the type of airiness and frivolity—instead of being despised, will some day be valued as one of the most important branches of biological science.' In this case the seer may be said to have brought about the fulfilment of his own prophecy by the inspiration given in his epoch-making theory of mimicry.

Department has been that very study of Warning Coloration and Mimicry from which, as an American naturalist has recently stated, 'the theory of natural selection as applied to Insects receives its strongest support'¹. Indeed the reference to Insects might safely be omitted; for the facts brought to light in the pursuit of this study furnish what is probably the most convincing of all evidence in support of the Darwinian hypothesis.

In the meantime the systematic side of the Department has occupied a large amount of time and care. It has not been found that the two courses indicated by Professor Huxley are by any means mutually exclusive. The measure of success which has attended the attack on the larger problems has been due in great part to the existence in Oxford of a splendid general collection—taking all the groups of Insects into account, the second in the British Empire.

Such success as the Hope Department has achieved in these two directions has been due to many causes:—to the energy and sympathy with which my Assistants, Mr. W. Holland and Mr. A. H. Hamm, have entered into the various researches which we have undertaken together; to the important investigations carried on by Dr. Dixey; to the recognition of Oxford as a centre where these problems are studied. The result of this latter influence has been the continual and ever-increasing accession of material and observations from all parts of the world. The inflow from Africa has been so large that the present volume of Reports is entirely occupied with the problems of Ethiopian zoology. This solid contribution to the

¹ A. G. Mayer, Science Bulletin of the Brooklyn Museum, Vol. I, No. 2, Oct. 1902, p. 36.

natural history of the great continent which occupies so dominant a position in our thoughts is mainly owing to a great Rhodesian naturalist, Mr. Guy A. K. Marshall; but a fruitful correspondence is also being carried on with English naturalists in British East Africa, Uganda, British Central Africa, Southern Nigeria and the Soudan. It is a pleasure to reflect that years before we knew of the great ideas for Oxford which were maturing in the mind of Cecil Rhodes, the Hope Department was steadily making itself recognized as a centre for the study of African natural history. There is also great satisfaction in the knowledge that so large a proportion of those who are in touch with the Department are Oxford men, receiving help and advice long after they have ceased to reside—glad on their part to think that they are helping one of the institutions of their University.

The amount of work done in ten years is undoubtedly encouraging, but there is an aspect of it which is the reverse. The steady increase in the collections, due to the work of the Department becoming more and more widely known, has gradually occupied a larger and larger share of my time and that of my Assistants, until finally we have reached a point at which the accessions of each year can barely be brought into a fit condition for cataloguing and incorporation, while nothing is left for the vast mass of the old collections, which imperatively demand a large amount of attention. It is essential that the Department should have further assistants with the mechanical skill necessary for the manipulation of old and brittle specimens. I do not wish to make too much of the demands upon my own time and energy for work of a more or less mechanical kind; but it is the fact that I wrote over 1,000 letters for the Department in the course of 1902. A considerable

proportion of the correspondence would, I trust, always fall to my share, but I hope that the time could be spent with greater profit to the University if it were possible to obtain some relief. I must also repeat what I have often said before, that for the library to be of any real value the catalogue must be completed; while for the safety of the books a large sum must be spent on binding. The University accepted over forty years ago one of the most complete and valuable of then existing libraries which dealt with the material of the Hope Collections. It is not creditable that no steps have been taken to complete a catalogue which is now so imperfect as to be useless, and that an immense number of valuable monographs should be endangered, and many should be injured, for want of binding. And, as regards the Collections themselves, there is the continual and pressing need for more accommodation in safe and well-made cabinets, and the removal of all that are unsafe and indeed extremely dangerous.

A great deal has been done during the past ten years. In addition to the endowment of the Hope Chair, which has now sunk to under £380, the grant of £150 a year paid by the University for salaries, the Hope Department endowment of about £48 a year, and the Spilsbury endowment of about £4 10s., in addition to these yearly payments a sum of nearly £1,850 has been spent on the Department, a very solid help towards the making good of some deficiencies mentioned above. Of this sum rather over half has been contributed from various University sources—from the Common University Fund £515, from the Delegates of the Museum £266, from Convocation £150; and £800 has been spent on cabinets, £50 on book-binding, and the remainder on miscellaneous needs. A sum of £900, nearly half the whole

expenditure on these deficiencies, has been raised by friends of the University and the Hope Department, and chiefly by my own College, which has come to the assistance of a hard-pressed University institution, electing me to a Fellowship, with the full knowledge that the yearly income would be applied to University purposes. Of this £900, exactly three-quarters, £675, has been spent on cabinets, £120 for special work upon the Collections, and the remainder in adding to the Collections.

Much has been done, but increased activities have brought increased needs. It is impossible, at any rate for some time, to expect adequate help from the University. I must, therefore, look for assistance to those who sympathize with the aims of the Hope Department, and value the work of which these volumes of Reports are the evidence.

EDWARD B. POULTON.

HOPE DEPARTMENT OF ZOOLOGY,
UNIVERSITY MUSEUM, OXFORD.

February 9, 1903.

'Semper Africa novi aliquid apportat.'

NOTE.—In reference to the Latin quotation on the title-page and cover of this volume I have adopted the form given by Erasmus in the *Adagia* (ed. 1528 [Basle], p. 767). His note runs: 'Huic simillimum est illud Plinianum, quod in historia mundi refert, Libyam semper aliquid novi adferre. Quod quidem ideo dicebatur, quod in siticulosa regione ad unum aliquem rivum plurimae ferarum species bibendi gratia convenire cogantur: inibique varia mixtura violentiae Veneris, varias monstrorum formas, subindeque novas nasci. Porro Plinius sumpsit ab Aristotele, apud quem refertur libro de generatione animalium secundo capite quinto. Anaxilas apud Athenaeum libro decimo quarto festiviter ad rem detorsit.' The preceding 'adagium' is *Semper adfert Libya mali quippiam*.

There does not appear to be any authority for the form in which the quotation usually appears—'Ex Africa semper aliquid novi.' My friends, Mr. C. E. Doble and Mr. W. G. Pogson Smith, have kindly helped me to trace the quotation.

E. B. P.

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[Read March 19th, 1902.]

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1. SEASONAL DIMORPHISM IN *Catopsilia pomona*, Fabr.

I HAVE long been of opinion, from the examination of many hundred specimens, that no line of specific demarcation can be drawn between *Catopsilia pomona*, Fabr., and *C. crocale*, Cram. This conclusion was based mainly on the fact that, distinct in appearance as typical examples of the two forms undoubtedly are, it is easy to arrange a series of examples showing every possible gradation between the two. The relation between *C. pomona* and *C. crocale* so much resembles that between forms which there is reason for regarding as cases of seasonal dimorphism, that I was led to suspect that the dimorphism of *C. pomona-crocale* might also have a seasonal significance. In 1898 I mentioned my suspicion to Mr. Trimen, showing to him at the same time a good series, including many transitional forms, of *C. pomona*, which had been captured near Brisbane in 1897 by T. Batchelor, and presented to the Hope collection by Mr. G. C. Griffiths. This series was noticed by Mr. Trimen in his Presidential Address to the Entomological Society of London, delivered on January 18, 1899, and was considered by him as "lending some probability to the view

that *C. crocale* and *C. pomona* (including *C. catilla*) will prove to be seasonal forms of one species." * Direct evidence on the point was, however, lacking; and I therefore welcomed a statement made later by Batchelor in a letter from Brisbane, and kindly communicated to me by Professor Poulton, that *C. crocale* and *C. pomona* were one species, "*crocale* being the summer brood and *pomona* the autumn one." It does not appear that any observer has as yet actually bred one form from the other, so that it cannot even now be said that their specific identity is proved with absolute certainty. Nevertheless, the opinion of a collector who has taken large numbers of both forms is of weight, and may safely be held to indicate a strong probability that, at all events in part of their range, *C. pomona*, Fabr. and *C. crocale*, Cram. are seasonal phases of the same species.

It is, however, evident that the case with regard to *C. pomona* is not quite a simple one. In the autumn of 1900, a series of eighteen specimens of *Catopsilia* was received by the Hope Professor at Oxford from the late Mr. L. de Nicéville, who stated that they were all caught nearly at the same time in the Kangra Valley, Western Himalayas, by Mr. G. C. Dudgeon. Of these eighteen, sixteen were taken on August 11, and the remaining two on August 13, 1900. Two of the captures on August 11 were *Catopsilia pyranthe*, Linn.; and of the remainder, eight were *C. crocale*, Cram., and six were *C. pomona*, Fabr. Those caught on August 13 were *C. crocale* ♂ and *C. pomona* ♀ taken in copulâ. In two private letters to the Hope Professor, Mr. de Nicéville appeals to this series of specimens in support of the view that *C. pomona* † and *C. crocale* constitute one

* Proc. Ent. Soc. Lond., 1898, p. lxxvi. It is hardly necessary to recall the fact that this address of Mr. Trimen's contains an excellent account of nearly all the experiments and observations that had been made on the subject of seasonal dimorphism in butterflies up to the time of its delivery.

† De Nicéville calls it *C. catilla*, Cram.; but the latter name, under which Cramer figures the form with brownish-crimson patches on the under-surface (see Cramer, Pap. Exot., III. t. 229, D, E), is later than that of Fabricius. Fabricius's type still exists in the Banksian cabinet, where I have examined it in concert with Dr. A. G. Butler. The six specimens of *C. pomona* caught on August 11 include two *C. catilla*, Cram. The British Museum contains six specimens of *C. crocale* and seven of *C. pomona* caught by Mr.

variable species, the variation not being due to seasonal causes. This view was published by de Nicéville in 1894, and was reiterated by him on several subsequent occasions.* There can be no doubt that de Nicéville's opinion receives support from the present series of specimens. The fact of *C. crocale* ♂ pairing with *C. pomona* ♀ tends to show their specific identity, while the simultaneous occurrence of the two forms in presumably equal numbers seems adverse to the supposition that the dimorphism of this species has a seasonal significance.

With regard to the first point, that of specific identity, I think there can now be no reasonable doubt that the case is made out. I have already mentioned my own conviction on the matter, which was arrived at independently, and on different grounds. Batchelor's observations here coincide with de Nicéville's; and it may be added that Piepers,† who has bred the species in large numbers, is strongly of the same opinion. On the other hand, Dr. L. Martin, writing of the butterflies of Sumatra (Journ. Asiat. Soc. of Bengal, LXIV, ii, p. 490, 1895), considers *C. crocale* and *C. catilla* (*pomona*) distinct, on the following grounds:—*C. crocale*, the far commoner form, occurs on roads, near houses and gardens, and is never found in the forest. *C. catilla* is found only in the forest. The antennæ of *C. crocale* are black in both sexes, those of *C. catilla* are red. The underside of the males in *C. crocale* is unspotted, and the tuft of hair on the inner margin is whitish. In *C. catilla* the males, like the females, have reddish spots on the underside of both wings, and the tuft of hair is

Dudgeon on the same occasion (August 12) as those mentioned above. They are stated to have formed part of a migratory flight which lasted all day.

* Gazetteer of Sikkim, p. 166, 1894; Journ. Asiat. Soc. Bengal, LXIV, ii, p. 490, 1895; Journ. Bombay Nat. Hist. Soc., xi, p. 586, 1898; Journ. Asiat. Soc. Bengal, LXVIII, ii, p. 211, 1899. The first two of these are cited by Mr. Trimen, *loc. cit.*, p. lxxvi, note.

† "Die Farbenevolution bei den Pieriden," Tijdschr. der Nederlandsche Dierk. Vereenig.; (2) Deel V, p. 119, 1898. Piepers gives *thauruma*, Reak., as a synonym; the latter, however (from Madagascar), is unquestionably distinct. "*Pomona*, Cram." (*ibid.*) is a slip; the name was bestowed by Fabricius. Piepers's view was first published in 1891—"Observations sur des vols de Lépidoptères"—Natuurkundig Tijdschrift voor Ned.-Indië, Dl. L, 1891, pp. 205, 222. In the same periodical, Dl. LVII, 1898, he repeats it, but speaks, rather curiously, of "*Gnoma*, Feld.," as a form of "*Catopsilia pomona*, Cram." (*loc. cit.*, p. 111).

distinctly yellow. The females of both forms are variable, but the range of variation is distinct in the two. De Nicéville, however, rightly remarks that "the distinctive characters on which Dr. Martin relies are all quite inconstant, and entirely break down" when large numbers of both forms are examined. It may be added that the difference of habit alleged to exist between *C. crocale* and *C. pomona* is no disproof of specific identity, inasmuch as a similar difference, witnessed to by both Trimen* and Marshall,† obtains between *Precis sesamus*, Trim. and the southern representation of *P. octavia*, Cram. (called by Marshall *P. octavia-natalensis*). The form *natalensis*, according to Marshall, frequents high, open spots; *sesamus* is shade-loving, though it occasionally flies with *natalensis*, especially at the change of seasons. *Sesamus* is more wary than *natalensis*; it is more often found in gardens, and occasionally enters human habitations. It also contrasts with *natalensis* in being at times gregarious. But in spite of these well-marked divergencies of habit, the two forms, as is well known, have been absolutely proved to be seasonal phases of the same species. Hence, in the case of *C. pomona* and *C. crocale*, Dr. Martin's objection on the score of habit cannot be held any more conclusive than that founded on the difference in aspect.

With regard to the second point, that of the seasonal relations of the two forms, it seems that the utmost we can at present allege is that in part, at all events, of its range the dimorphism of *C. pomona* is associated with the change of season. That this is not the case everywhere is evident from de Nicéville's observation, as quoted by Trimen,‡ that "the innumerable varieties which are found in both sexes occur at all times;" and, more particularly, from the statement that "both true *C. crocale* and the dimorphic form, *C. catilla*, Cram. occur commonly in Mussoorie from July to October, and in Dehra Dun throughout the warmer months of the year."§ On the other hand, we have Batchelor's categorical assertion from

* South-African Butterflies, vol. I, 1887, pp. 230, 233.

† Ann. Mag. Nat. Hist., 1898, vol. II, pp. 33, 34.

‡ Proc. Ent. Soc. Lond., 1898, p. lxxvi.

§ Mackinnon and de Nicéville, Journal of Bombay Nat. Hist. Soc., vol. XI, 1898, p. 586. Piepers also denies absolutely that the dimorphism of *C. pomona* is seasonal ("Notes from the Leyden Museum," vol. XXII, 1899, note 1, p. 13, *ibique cit.*).

Brisbane, given above; while the fact recorded by Dr. Martin (*loc. cit.*) that among many hundreds of both sexes of *C. crocale*, all presumably belonging to one emergence, taken by him near Bindjei, there was not a single *C. catilla* (*pomona*), may possibly have a similar significance.*

It is not a little remarkable that although there are forty-three specimens of *C. pomona* and *C. crocale* in the Hope collection duly labelled with locality and date, they cannot be said to throw much light on the question of seasonal dimorphism. What is wanted is a long series of observations carefully carried on in one locality, and accompanied, if possible, by breeding experiments.

If, as is probable, it should eventually be shown beyond doubt that the different forms of *C. pomona*, though related to the seasons in some part of its range, occur indifferently at all times in others, the case would by no means stand alone. I propose in the next place to notice very briefly several statements that have been made by different authorities with regard to other species, which statements tend to show that in many cases where the existence of seasonal modification has been reasonably presumed, or even actually demonstrated, the seasonal relation is far from being rigidly fixed in all parts of the area of distribution.

2. SEASONAL DIMORPHISM IN *Catopsilia pyranthe*, Linn.

The first instance that may be taken is that of *Catopsilia pyranthe*, Linn. This butterfly grades imperceptibly into *C. gnoma*, Fabr. just as *C. crocale* does into *C. pomona*. Here again, in the absence of breeding experiments, the absolute proof of specific identity is still lacking; but de Nicéville had no doubt, from his own observations, that the two forms represent a single species. In this case he is able to assign a seasonal value to the two forms,—*C. pyranthe* being in his opinion the wet-season, and *C. gnoma* the dry-season phase of the species. But the point of special interest, in view of the irregularity that appears to obtain in the seasonal relations of *C. crocale* and *C. pomona*,

* It should, however, be noted that "N.-E. Sumatra does not possess a well-marked dry and wet season, such as is found over most of the continent of India, there being no month in the year when it does not rain." Journ. Asiat. Soc. Bengal, LXIV, 1895, pt. ii, p. 362. See below, p. 196.

is the fact that, as recorded by de Nicéville himself, the different forms of *C. pyranthe*, though corresponding to the seasons in some parts of its range, are independent of them in others. Thus, in speaking of this species under the name of *C. chryseis*, Drury, he notes that "it is not seasonally dimorphic in Sumatra as it is in India." * Again, he remarks under *C. pyranthe*, "Moore in the 'Lepidoptera of Ceylon' gives four forms of this species as separate species; *C. gnoma*, Fabr., *C. ilea*, Fabr., *C. chryseis*, Drury, as well as typical *C. pyranthe*. Manders notes that as far as his observations go these four forms are not dependent on season, but appear indiscriminately nearly throughout the year, those flying in the dry season from February to April being a little smaller than those found during the rest of the year." † On the other hand he says, "True *C. pyranthe* is not very common in Mussoorie in the rains; the dry-season form, *C. gnoma*, Fabricius, even less so. In the Dun both forms are common in their respective seasons." ‡

If then we are to trust the observations that have been cited, we are led to the conclusion that in these *Catopsilias*, viz., *C. pomona* and *C. pyranthe*, we have to deal with two polymorphic species, each of which has no doubt several geographical forms, and each of which shows, in most localities, a special tendency to cleavage into two well-contrasted types. These latter phases in each case are in some parts of the range of the species dependent on seasonal changes; in other parts, however, they show no such connection.

We may now pass on to the consideration of similar irregularities as shown in other groups.

3. IRREGULARITIES OF SEASONAL DIMORPHISM IN VARIOUS GENERA.

It has been recorded by most of those who have experimented on the subject, that there are individual differences in the reaction of members of the same brood to what appear to be identical conditions of the environment. A conspicuous instance of this is the well-known

* Journ. Asiat. Soc. Beng., LXIV, 1895, ii, p. 490.

† *Ibid.*, LXVIII, 1899, ii, p. 211.

‡ Journ. Bombay Nat. Hist. Soc., XI, 1898, p. 586.

experience of Mr. Marshall, who in April 1898 bred a specimen of *Precis sesamus* and another of *P. octavia-natalensis* from two eggs, laid on the same day by the same mother, and reared under precisely similar conditions.* Dr. Butler has also put it on record that Captain Nurse bred *Teracolus yerburii*, Swinh., and *T. nouna*, Luc.,† from a batch of similar larvæ, the perfect insects presumably emerging at the same season. Many cases have been observed where, although each of the two forms of a species is on the whole confined to its own time of year, there is yet a considerable amount of overlapping at the change of seasons; this overlapping showing itself both by the simultaneous occurrence of freshly-emerged specimens of both phases, and also by the appearance of a more or less complete series of "intermediates." A good instance of the simultaneous occurrence, in the field, of different phases believed on strong grounds to be seasonal, is afforded by the capture of all three forms ("wet," "dry," and "intermediate") of *Precis sesamus* by Mr. Crawshaw at Nairobi within little more than a week during the month of April.‡ Many records of this kind are in existence; and are often, no doubt, to be ranked as examples of the seasonal overlapping that has just been mentioned.

It is however evident that there are numerous cases of simultaneous occurrence which cannot be brought under this head. Besides the definite statements of de Nicéville with regard to two species of *Catopsilia*, we have now a considerable bulk of evidence, with regard to many species, of the appearance side-by-side, at all times of year, of forms closely analogous with what are now well established as seasonal phases. Thus, again according to de Nicéville, the ocellated and non-ocellated forms of *Melanitis leda*, Linn., which he has shown to be related in India to the wet and dry seasons respectively, both occur in North-East Sumatra all the year round. In Java it has been

* Ann. Mag. Nat. Hist., 1898, vol. ii, p. 30.

† More accurately, perhaps, *T. evagore*, Klug. *T. nouna* is the dry-season phase of the African form *T. daiva*, Klug. Capt. Nurse's larvæ were found at Shaik Othman, and no doubt belonged to the Arabian form, of which *T. yerburii*, Swinh., is the wet, and *T. evagore*, Klug, the dry-season phase. This is pointed out by Butler in Ann. Mag. Nat. Hist., 1897, vol. ii, p. 460. The original record is in Proc. Zool. Soc., 1896, p. 247.

‡ Proc. Zool. Soc., 1900, p. 916.

noted by Piepers * that the non-ocellated form, though on the whole belonging chiefly to the dry season, is also to be met with during the rains. It is true, as Piepers says, that in Java, as in the Malayan Islands generally, the distinction between dry and wet season is not so sharp as on the Indian mainland; so that a certain amount of intermingling of the two forms might perhaps have been antecedently expected. It does not appear, however, that all dimorphic species are affected by these or the like conditions in the same way. De Nicéville points out, in a passage quoted by Trimen, that with this exception of *Melanitis leda* there are no dry-season forms in North-east Sumatra; and Doherty mentions analogous facts in reference to localities with a generally moist climate, like Ceylon and Singapore, and also, *mutatis mutandis*, to dry countries like Sind.† The prevalence of wet-season forms in the equatorial forest region of West Africa is another phenomenon of the same kind. Instances such as these show that a generally damp country may be characterized by a greater abundance of "wet-season" forms, and *vice versa*. But these cases of the prevalence of "dry" or "wet-season" forms respectively, according to the general climatic conditions of a given locality, are, as we have just seen, accompanied by others which seem to prove that in certain districts, especially perhaps dry ones, the phases that are usually associated with the seasons occur indiscriminately at all times of the year.

Many such instances are recapitulated by Butler in his late revisions of the genera *Teracolus* and *Terias*. *Teracolus eupompe*, Klug, for example, has a wet, an intermediate and a dry phase. "The two latter undoubtedly fly together, and in Aden it is tolerably certain that all the phases emerge at the same time as mere variations."‡ With regard to *T. halimede*, Klug, Butler observes, "*T. acaste* represents the wet-season phase, *T. halimede* the

* "Die Farbenevolution bei den Pieriden," Tijdschr. der Nederl. Dierk. Vereenig; (2) Deel V, 1898, pp. 179—185, etc. The value of the theoretical considerations based by Piepers on the facts that he has evidently observed with much care, appears to me to be greatly diminished by his refusal to admit the influence of selective adaptation, even as a provisional hypothesis.

† Proc. Ent. Soc. London, 1898, p. lxviii. Compare Watson; Journ. Bombay Nat. Hist. Soc., 1894, vol. viii, p. 489, etc.

‡ Ann. Mag. Nat. Hist., 1897, vol. ii, p. 497.

intermediate, and *T. celestis* the dry-season phase of the species; but they are none of them confined to seasons, but occur (as is the case with other species in very arid countries) as mere coexistent variations." * Of *T. protomedia*, Klug, he remarks, "At Aden all three [seasonal] types occur together as mere variations." † Other species of *Teracolus* of which similar statements are made are *T. protractus*, Butl., *T. phisadia*, Godt., *T. puellaris*, Butl., *T. vestalis*, Butl., *T. evagore*, Klug, and *T. pleione*, Klug. With regard to *Terias* Butler also notes that, "as in *Teracolus*, those countries which have no wet season nevertheless produce the three phases of a species as coexistent varieties." ‡ There is reason to think that in the New World, at any rate, there may occur a similar intermingling of forms which is not confined to "countries having no wet season." Thus, Messrs. Godman and Salvin write as follows: "Many of these forms [of *Terias*] are said to be due to the season of the year at which they appear, wet-season and dry-season broods having each their peculiar characteristics. These observations have been made chiefly in the east. In our country we have not noticed any phenomenon of this kind." § Mr. G. C. Champion again, if my memory does not deceive me, in the discussion that followed the exhibition of certain specimens of *Callidryas* referred to by Mr. Trimen (*loc. cit.*), many of which were collected by himself, stated that according to his experience of these butterflies, the varying forms of the same species from the same locality had no definite relation to the seasons. Colonel Swinhoe, besides recording the fact that he has taken all the seasonal forms of certain eastern *Teracoli* flying simultaneously at Karachi, has also averred that he has captured *Byblia simplex*, Butl., the supposed dry-season form in India of *B. ilithyia*, Drury, practically all the year round. Some doubt has been thrown by de Nicéville and by Marshall on the latter observation; the

* Ann. Mag. Nat. Hist., 1897, vol. ii, p. 502. The dates of Col. Yerbury's captures at Aden clearly prove the simultaneous occurrence of different "seasonal" forms, but they do not seem incompatible with a certain amount of correspondence on the part of these phases with the time of year. See, e.g., the dates given for *Teracolus celestis* and *T. acaste*; Proc. Zool. Soc., 1884, pp. 489, 490.

† Ann. Mag. Nat. Hist., 1897, vol. ii, p. 507.

‡ *Ibid.*, 1898, vol. i, p. 57.

§ Biologia Centrali-Americana. Rhopal. ii, p. 154.

former, however, says Butler, is a fact that can be proved from the data on the Museum specimens.*

Statements of this kind, the list of which could be largely extended, go far to show that the case of *Catopsilia pomona* and *C. crocale* is by no means an isolated one, and that just as there are regions in which more than one geographical form of a widely-ranging species may be found flying together,† so there are districts of a greater or smaller extent where diverse forms of a species, confined for part of its range to definite seasons, may all occur simultaneously. No doubt the data are as yet insufficient for a complete explanation of these phenomena. It seems, however, clear that the forms or phases which are usually called "seasonal" may occur under many diverse conditions and in many different proportions. It appears further that they do not fall into a regular system of succession, except in the presence of regular alternations of season, and not always then. I still venture to think that a probable view concerning many of them is that briefly expressed by me some years ago in "Nature" (Vol. lx; 1899, p. 98), viz., that polymorphism, however it may have arisen, is capable of being brought more or less into relation with locality and season under the influence of natural selection. On the other hand, it is conceivable that in some cases at all events the forms in question may have first arisen as adaptations to the seasonal changes, and afterwards, in consequence of extending their range, or of some other alteration of conditions, may have partly or entirely lost

* Ann. Mag. Nat. Hist., 1897, ii, p. 386; *Ibid.*, 1896, ii, p. 335. The following instances may be added from specimens with data in the Hope collection:—(1) Australian form of *Terias hecabe*, Linn. (*T. sulphurata*, Butl.); the dry, wet, and intermediate seasonal forms, all taken by Mr. J. J. Walker, R.N., on June 19, 1890, at Port Darwin, North Australia. (2) *Teracolus phleggyas*, Butl. (*T. difficilis*, E. M. Sharpe); a wet-season male taken paired with a dry-season female, both in good order, by Mr. G. A. K. Marshall, May 3, 1899, at Salisbury, Mashonaland. (3) *Teracolus vestalis*, Butl.; the wet and dry-season forms both taken at Karachi on May 10, 1888, by Mr. W. D. Cumming. (4) *Belenois severina*, Cram.; wet and dry-season forms both taken on Feb. 13, 1897, at Karkloof, Natal; a wet-season male paired with a wet-season female, and another wet-season male with a dry-season female on Feb. 24, 1897, at Malvern, Natal. All these by Mr. G. A. K. Marshall.

† *E.g.* the various forms of *L. chrysippus*, Linn., which are all found together at Aden. See Butler in Proc. Zool. Soc., 1884, pp. 478-481; and Col. Yerbury in Journ. Bombay Nat. Hist. Soc., 1892, p. 209.

their correspondence therewith. These are questions that must, I think, for the present remain unanswered; though whatever the solution may be, there seems no need to anticipate that it will weaken the case for selective adaptation.

4. EXPERIMENTS AND OBSERVATIONS IN SEASONAL DIMORPHISM CONDUCTED BY MR. G. A. K. MARSHALL, F.Z.S., IN THE YEARS 1896—1901.

In the "Annals and Magazine of Natural History," 1901, ii, p. 403, Mr. Marshall writes as follows:—"Two years ago I made a few experiments in applying moist heat to the pupæ of several species of *Teracolus*. Unfortunately all my notes on the subject have been lost, but, so far as I can recollect, the results were almost entirely negative, which I then attributed to insufficient heat. The resulting specimens were, however, sent to the Oxford University Museum with full data." There are also in the Hope collection several other specimens, collected by Mr. Marshall in 1896 and following years, which are of considerable interest in their bearing on the subject of Seasonal Dimorphism. By the kindness of the Hope Professor, I am permitted to give Mr. Marshall's own comments on both series of specimens. These are contained in private letters to Professor Poulton, and have not hitherto been published. I propose to arrange the notes in chronological sequence; but it will be seen that the experiments fall into two main groups, which are more or less intermingled in order of time. The first group of experiments includes cases where one form of a species was reared under normal conditions from eggs laid by another form of the same species. In the second group of experiments, the pupæ, or sometimes the larvæ in their later stages as well as the pupæ, were subjected to artificial conditions in order to see whether any effect could be thereby produced on the following emergence. It is well known that very striking results have been brought about by artificial conditions of temperature in the case of dimorphic butterflies in Europe and North America. The names of Dorfmeister, W. H. Edwards, Weismann, Merrifield and Standfuss, to say nothing of others, will occur to every one as those of the authorities to whom we owe nearly

the whole of our knowledge in this particular. In view of the great difference between the temperate and tropical seasons, it was natural to suppose that the seasonal forms of tropical butterflies would be found to stand in relation to quite other meteorological conditions than those responded to by the Nearctic and Palæarctic species which had previously formed the subject of experiment. So far as I am aware, the only factor found generally operative in these latter cases is a raising or lowering of the temperature; the direct effect of humidity has been tried, but almost always with negative results. Mr. Marshall, on the other hand, has successfully used heat in combination with both moisture and dryness, and has also employed moisture unaccompanied by heat. By all these means, as will be seen, he has secured results analogous indeed with those of the European observers, but as a rule far less complete. It is possible that there may still be discovered some factor or combination of factors which will produce, in dimorphic tropical species, equally striking results with those to which Merrifield and Standfuss have now accustomed us. Most, however, of the species so far investigated by Mr. Marshall have proved comparatively resistant to this kind of treatment, and he has no instance of artificial modification which can be ranked with the *Araschnia levana* of many experimenters, or the *Selenia tetralunaria* of Mr. Merrifield.

Mr. Marshall's initials are here appended to each separate extract from his correspondence.

"*Estcourt, Natal; Dec. 14, 1896.*—I only succeeded in getting three eggs of *Teracolus topa**, of which I send you one of the resulting specimens, which is undoubtedly *T. auxo*, being of the early wet-season form with the upper side black markings not yet fully developed. The eggs were laid within five minutes of one another, and they hatched simultaneously, but one larva pupated a day later than the other two and emerged a day later. The first two examples

* The result of this experiment was communicated by Mr. Marshall to the "Entomologist's Monthly Magazine," 1897, p. 52, and is referred to by Mr. Trimén in his address above quoted (Proc. Ent. Soc. Lond., 1898, p. lxxii). It should be noted that the name *T. topa*, Wallgrn., which is now used by both Mr. Marshall and Mr. Trimén to designate the dry-season form of *T. auxo*, is considered by Dr. Butler to be applicable rather to an intermediate form between *T. auxo* and *T. keiskamma*, Trimén, the latter being the true dry-season phase. (Ann. Mag. Nat. Hist., 1897, ii, p. 453.)

(of which yours is one) are quite similar, but the third has the black edging to the apical patch of the forewing a trifle heavier, and also shows a trace of the black line along the inner edge of the patch characteristic of the full summer form. As the eggs were all laid by the same female, and the larvæ were reared under absolutely similar conditions, it would seem at first sight that the heavier markings could only be due to the longer larval stage, but this seems highly improbable. I was astonished at the rapid development of this species; egg-stage, three days; larval stage, twelve to thirteen days; pupal stage, eight days. Total, twenty-three to twenty-four days. From this I should estimate that there must be from nine to ten broods in the year."—G. A. K. M.

The above-mentioned specimen, a male, is now in the Hope collection, and entirely bears out Mr. Marshall's description. It is a well-marked, but not extreme example of the "wet-season" form *T. auxo*, Luc. Mr. J. Mansel Weale's experience of the same species is well known; * and it may be noted that of five bred examples sent to the Hope collection by Mr. Weale in 1878, there is a pair each of the *auxo* (wet) and *topha* (dry) form, together with a single female of an intermediate phase. Mr. Marshall's experiment removes the subject of the specific identity of these several forms from the region of probable conjecture to that of proof.

"*Estcourt*, Dec. 14, 1896.—While staying with Mr. Burn, at the junction of the Blaauwkraantz River with the Tugela, I tried to see whether the black markings of the early wet brood of *Teracolus annæ* could be intensified by damp surroundings, so as to resemble those of the full wet form. For this purpose I had a tin half filled with wet sand, in which I stuck the pupæ on thin sticks, covering it over with a cloth on which was a wet sponge. Into this I put five freshly-turned pupæ, of which I kept three in for seven days and two for nine. Only one specimen emerged out of each lot, and so far as I can see there is absolutely nothing unusual about either of them. Although the results of the experiment are negative, they are interesting, in that they *tend* to show that cold moisture cannot accentuate the black markings of the wet-season form, and also that cooler surroundings (induced by evapor-

* Trans. Ent. Soc. Lond., 1877, p. 273. See also Mr. Barker's comments; *Ibid.*, 1895, p. 422.

ation) do not tend to cause a reversion to the dry-season form. The first lot of *T. annæ* I bred (under ordinary conditions) were in pupa during fine warm weather, and took nine days to emerge. Those placed in the damp tin took in both cases twelve days. Three other pupæ kept under ordinary conditions were also twelve days in pupa, the last six days being cold, wet weather; these however were all of the full wet form, one female being even blacker than usual. With this species I observed that the bred specimens were nearly always more advanced in coloration than freshly emerged captured specimens."—G. A. K. M.

Eight of the specimens of *T. annæ*, Wallgrn. above referred to, are now in the Hope collection. One of these emerged on Nov. 17, 1896, after a pupal stage of twelve days, during seven of which it was kept in the damp tin jar, as above stated. It is an ordinary wet-season male, not extreme in character. A well-marked wet-season female, also in pupa twelve days, but under usual conditions, emerged on Nov. 11. This may be the female mentioned above. The only other bred specimen is a well-marked wet-season male, decidedly darker than the first. It emerged on Nov. 13, but there is no note as to its duration in the pupal state. The remaining five specimens were caught in the open. A female taken on Nov. 6 is wet-season; a pair on Nov. 12 are intermediate, as are two males taken on Nov. 14 and Nov. 16 respectively.

"*Estcourt, Dec. 14, 1896.*—On my return here I attempted a small test experiment as a converse of the former one, viz., submitting pupæ to dry warm conditions. My *modus operandi* was as follows: on a tripod stand I placed a round tin containing a little water; on the mouth of the tin was a china saucer filled with dried sand, in which were placed the pupæ beneath an inverted glass, the water being warmed by a spirit-lamp. Into this I put a suspended larva of *Byblia lithyia*, a pupa seven days old, and another two days old. I applied too much heat at first, keeping the water at a boil, which killed the larva. I then turned the lamp as low as possible, keeping the tin just hot enough for the hand to bear. The older pupa emerged in three days (normal pupal stage, thirteen to fifteen days) and presents no marked peculiarity, as you may see, being of the early wet-season form, which was the only form occurring at that time in the natural state. The last

pupa emerged after six days' heating (eight days in pupa); unfortunately it had a difficulty in emerging, and I arrived too late to help it. But such as it is, it seems to me a very interesting specimen, for it is clearly intermediate in colouring, being therefore a step backwards towards the dry form. Its intermediate character is shown on the underside of hind wings, in the deeper ground-colour and more accentuated white bands, and on the upper side by the broad interruption about radial nervules of the sub-marginal black line in forewings, a character which only occurs in the dry or intermediate form of the female, and never in the early wet form of that sex."—G. A. K. M.

The two specimens here mentioned are both in the Hope collection. The difference between them is marked, the one which emerged on Nov. 27, from the pupa which was already seven days old before being exposed to dry warmth, being a wet-season male of the ordinary kind; while the other, which was only two days old when subjected to the same dry warmth, emerging on Nov. 30, is a crippled female, distinctly of the dry-season form, not extreme, but quite unmistakable, and entirely differing from specimens captured in the same locality at the same time of year.

"*Malvern, Natal; Feb. 21, 1897.*—I have been trying to find some reason to account for the occurrence of the marked varieties of *Biblia ilithyia*. This again is a widespread and common species, and comparatively conspicuous, so that there must be some sort of protective agency at work. I can only explain it by the fact that *B. ilithyia* strongly suggests an *Acræa* on the wing. Its general coloration, somewhat elongated wings and flapping flight (so different from that of its congeners), all tend to suggest this. That the typical form does not actually resemble any species of *Acræa* is of course plain, but I certainly regard the variety *acheloia* as a marked stage of incipient mimicry. On the underside, the hindwing of this variety, in its wet-season form, differs from that of the type in having lost the whitish bands, which gives it a very marked resemblance to *Acræa serena-buxtoni*. Again, the loss of the discal row of spots on the upper side of the hindwing points the same way, and it is interesting to note that, so far as my experience in South-east Africa goes, where *A. serena-buxtoni* occurs, there *acheloia* prevails over the typical form. Again, the chief difference between

the Central African *serena* and its southern sub-species is that in the former the black band near the apex of the forewing is continuous, but broken in the latter. If I remember right, there is a somewhat similar difference between *acheloia* and its Central African form *goetzius*, which, if correct, would further bear out my idea. Now as to the winter form; the underside of this is of course quite unlike that of any *Acræa*, and I can only suppose that it is a case of protective resemblance on the principle of the zebra's or tiger's stripes, for the insect always roosts on grass. It is interesting to note however that that part is undergoing modification in the variety *acheloia*, as the marginal white line in both wings has already done. It would be interesting to know whether there is any likeness between this species and the Indian *Acræas*."—G. A. K. M.

As I have elsewhere stated, I consider that *Byblia götzius*, Herbst, which Mr. Marshall here speaks of as *B. ilithyia* var. *acheloia*, is entitled to distinct specific rank beside *B. ilithyia*, Drury. Mr. Marshall's observation with regard to the continuity of the apical black band of the forewing in the Central African form of *B. götzius* is borne out on an examination of specimens in the Hope collection and the British Museum. It was remarked by me some time since, in discussing the modifications of *B. ilithyia* and its allies, that "the Socotran *B. boydi* resembles most specimens of *B. götzius* from the West African subregion in having the dark costal bar of the forewing continued rather heavily across the wing to join the submarginal band. This is also more or less the case with two females of *B. götzius* from Abyssinia, and specimens of the same from Somaliland and Aden in the British Museum; but in examples from South and East Africa the connection between the costal and the submarginal dark bands is often slight or absent."* It is worth noting that the marginal white line spoken of by Mr. Marshall, on the underside of both wings in the dry-season form of *B. ilithyia*, has disappeared from the dry-season *B. götzius*, but persists in *B. boydi*, of which only the dry-season form is at present known. This is another indication of the intermediate position of the latter insect, which, though nearer to *B. götzius*, yet shows several points of resemblance to *B. ilithyia*.

* Proc. Zool. Soc., 1898, p. 378.

On the whole Mr. Marshall's view as to the incipient mimicry of *Acræa serena*, Fabr., by *B. götzii* seems a very probable one. The underside of the wet-season *B. ilitzia* perhaps recalls slightly that of the Indian *Acræa* (*Telchinia*) *violæ*, Fabr., but the likeness in this case is of a remote kind.

"*Malvern, Natal; May 14, 1897.*—*Experiments on submitting pupæ to conditions of moisture or dry heat.* The apparatus used for dry-forcing was a covered tin (into which was poured a little water) placed on a tripod over a spirit-lamp. On the lid of the tin was placed some dried sand, into which was stuck a stick bearing the pupæ, which were covered with an inverted glass. The 'damp tin' contained very damp sand, the pupæ being separated from it by a grating of perforated zinc; and the mouth of the tin was covered with a cloth, on which was placed a wet sponge.

"EXPERIMENT WITH *Acræa cabira*.

1897

- March 26. Two larvæ (*a* and *b*) pupated this morning; I put them in the dry forcer in the evening.
 „ 28. A larvæ (*c*) pupated, and was left in the breeding-cage.
 „ 31. Two larvæ (*d* and *e*) pupated; *d* put in the forcer, *e* left in breeding-cage.
 April 6. *c* emerged, being a normal male.
 „ 8. *e* emerged, a normal female; *d* not yet emerged, but still alive; *a* and *b* probably dead.
 „ 9. *d* evidently too weak to emerge, so I helped it out, but it was only just alive, and wings did not expand. Its colouring was apparently normal. *a* and *b* never emerged at all, but shrivelled up.

"*Result.*—*Acræa cabira* apparently unable to exist in a very dry, hot climate, as might be supposed from its distribution. It is noteworthy that two pupæ of *Terias brigitta* emerged satisfactorily in forcer during the same period.

"EXPERIMENT WITH *Pinacopteryx pigea*.

1897

- April 2. Seven larvæ (*a* to *g*) pupated.

1897

- April 3. Put two pupæ (*a* and *b*) in dry forcer; two more (*e* and *d*) in damp tin; and left three (*e*, *f* and *g*) in breeding-cage.
- „ 9. Took *c* and *d* out of damp tin, as they showed signs of emergence.
- „ 10. *a*, *c* and *e* emerged in the morning. *a* was a female of the yellow form, showing an approach to the dry-season form in a slight reduction of all the black spots and borders, especially the discal spot in forewings; *c* was a female of the white form, and had all the black spots well marked; *e* was a white female, intermediate in the development of black markings between *a* and *c*.
- Removed *b* from forcer to breeding-cage.
- „ 11. *b*, *d*, *f* and *g* emerged. *b* was a white female in which the black markings were not quite so light as those of *c*, but noticeably lighter than those of *e*; *d* was a normal wet-season male; *f* and *g* were yellow females intermediate in markings between the extreme forms *a* and *c*.

“*Result.*—The differences exhibited are slight, but so far as they go they apparently tend to show that the effect of dry heat is to reduce the black markings, and that of cool moisture to enhance them. It is to be observed that yellow and white forms of the female occur at both seasons, the deeper yellow specimens are however more prevalent in winter. Reliable *seasonal* distinctions are greater or less development of the marginal black spots and discal spot in forewing, combined with less or greater acuteness of forewing.

“EXPERIMENT WITH *Crenis boisduvalii*.

1897

- April 9. Twenty-two larvæ of *C. boisduvalii* pupated.
- „ 10. Put six pupæ into dry forcer; six into damp tin; and left the rest in breeding-cage.
- „ 14. Six pupæ in forcer emerged; there were four male and two female, but two of the former were deformed.

1897.

- April 15. Three males and three females emerged in damp tin; one male escaped and another was deformed. Three males and six females also emerged in breeding-cage.

"On comparing the three sets of specimens the differences were found to be remarkably slight, all the specimens being of a more or less intermediate character between the wet and dry season forms (as might be expected during this month for those bred under normal conditions). But such slight differences as do exist appear to be fairly constant. In the females the black patches on the underside of the forewings are constantly best developed in those from the damp tin and least in those from the forcer. Those reared under normal conditions are much nearer the former in this respect, being all rather lighter, except examples which are hardly separable from those reared under moist conditions. The differences in the hindwings are too slight to be taken into account. In the males those from the forcer show a slight difference from the rest in having the black mark on the underside of the forewing somewhat reduced, and a greater suffusion of ochreous scales on the upper side of the hindwing. The others are practically inseparable. The seasonal differences in this species are very clearly defined as a rule.

"SECOND EXPERIMENT WITH *Pinacopteryx pigea*.

1897.

- April 8. Six larvæ pupated (*a* to *f*).
 „ 9. Two larvæ pupated (*g* and *h*). Put *a*, *b* and *c* into dry forcer, and *d* and *e* into damp tin.
 „ 10. Two larvæ (*j* and *k*) pupated. Put *g* into damp tin.
 „ 15. Removed *a* and *b* from forcer to breeding-cage; *c* was dead; cause unknown.
 „ 16. *a* and *b* emerged; both females.
 „ 17. *f* and *h* emerged in breeding-cage; both females.
 „ „ *d* emerged in damp tin; female.
 „ 18. *e* emerged in damp tin; female.
 „ „ *j* emerged in breeding-cage; female.
 „ 19. *g* and *k* emerged in damp tin and breeding-cage respectively; both males.

"No notes were kept of individual markings, but on comparing the three sets it was noticeable, as in previous experiments, that considering the disparity of conditions, the markings showed wonderfully little difference. It is however indisputable that, taking the specimens in conjunction with those of the previous experiment, all those subjected to dry heat had the black markings appreciably less developed than those whose pupæ were kept in a cool, moist atmosphere. Those that were reared entirely in the breeding-cage are mostly of an intermediate type of colouring, though two are quite as bright as the heated specimens, but none of them resemble those that were kept damp.

"It is noteworthy that in *Crenis boisduvalii* the specimens reared under normal conditions showed just the opposite tendency.

"Although the experiments are on far too small a scale to *prove* anything one way or the other, yet to my mind they appear to lend more support to the theory that the heavier development of black markings in South African butterflies during the summer is probably more dependent on the prevalence of moisture than on the action of heat: though the very small effects shown by these agents in the above experiments suggest the supposition that the absence or presence of black markings alone cannot be referred entirely to climatic agency, as I had been previously inclined to think, but have been developed by natural selection, for some purpose not at present apparent, which has worked on the slight tendency to variation caused by climatic influence."—G. A. K. M.

In 1896 Mr. Marshall had exposed some larvæ of *Acræa anacreon* to "dry-season" conditions just before pupation, but they all died in consequence, as he believes, of overheating (Estcourt, Oct. 15, 1896). On Oct. 7, 1897, he writes from Malvern: "The experiment in which I found that the pupæ of *Acræa cabira* were killed by dry heat which did not affect *Terias brigitta*, leads me to think some of these highly-developed nauseous species may have suffered in hardness of constitution, which would account for their not spreading more widely than they do."

Of the specimens referred to by Mr. Marshall in the two series of experiments on *Pinacopteryx pigea*, Boisd., *a*, *c* and *e* of the first series, and *a*, *b*, *d*, *e*, *f* and *h* of the second series are in the Hope collection. The divergences noted

as the result of the different treatment are more easily visible in the first series than in the second.

The Hope collection also possesses seven specimens of the above-mentioned series of *Crenis boisduvalii*, Wallgrn. These are a pair of the "dry heat" emergence on April 14; a pair of the "damp tin" emergence on April 15; and a male and two females which emerged under normal conditions, also on April 15. There is no doubt that the "dry heat" female is considerably lighter on the upper surface, and has the dark marks on the under surface of the forewings less distinctly marked than any of the others. The differences between the males are of the same kind, but somewhat less apparent.

"Aug. 29, 1899.—I am sending you by this mail a small lot of butterflies, including the bred *P. sesamius* and *archesia*, and twenty-one bred specimens of *Teracolus omphale* and *T. achine*, with their respective parents. . . . The *Teracoli* will be valuable as actually proving seasonal dimorphism in these species. I must admit that I was much surprised to find that the warm, damp atmosphere had no effect on *T. omphale* (D1—4) whatever.* The apparatus I used was a very deep circular tin (uncovered), which was partially filled with water, in which was placed a stand; to this the pupæ were pinned, they being about four inches above the water. In the case of *T. omphale* (D1—4) I kept the spirit-lamp with only a tiny flame, so as to keep the water just hot, and so that a faint warmth could always be felt on placing the hand above the mouth of the containing tin. On account of the negative results thus obtained, I came to the conclusion that the heat applied was perhaps insufficient in all these cases. Unfortunately, I had not enough material left to test this properly, but in the case of *T. achine* (C1 and C2) I kept the water at about 180° F., still keeping the tin uncovered, and, as you will see, this has undoubtedly had a more decided effect, especially in the case of C2, which was put in before actual pupation. I was, however, surprised that with C1 the protectively coloured under side should have been affected, rather than the black markings of the upper side. In view of this result I think the previous experiments must not be taken as conclusive. Among the *Teracoli* there

* It appears to me to have had a slight effect, as can be seen on comparing D2, D3 and D4 with D5, D6 and D7. See pp. 211-13.—F. A. D.

is a highly interesting female *omphale* (E, No. 15).”—G. A. K. M.

The specimens of *Teracolus* here spoken of were all obtained at Salisbury, Mashonaland. They are as follows:—

1. *Teracolus achine*, Cram.

X. A “wet-season” female (Figs. 5, 5a). Captured March 26, 1899. Laid one egg.

X1. Offspring of X. From egg laid March 26; hatched March 31; pupated April 23; kept under normal conditions; emerged May 9. A “dry-season” female, not extreme, corresponding to the form described by Trimen (South African Butterflies, vol. iii, 1899, p. 136) as *T. antevippe*, Boisd., ♀ (Figs. 6, 6a.)

B. An “intermediate” female. Captured April 23, 1899; laid 15 eggs.

B1. Offspring of B. Egg laid April 23; hatched April 29; pupated June 12; kept under normal conditions; emerged July 20. A dry-season male, corresponding to *T. antevippe*, Boisd., as described by Trimen, *loc. cit.*

B2. Offspring of B. Egg laid April 23; hatched April 29; pupated June 15; kept under normal conditions; emerged July 22. A well-marked dry-season male, the pink of the hindwing under side more pronounced than in B1. The left hindwing is not completely expanded.

C. An intermediate female, verging towards “dry.” Captured April 26, 1899; laid 17 eggs.

C1. Offspring of C. Egg laid April 26; hatched May 3; exposed to damp heat from 10 p.m., June 22, to 8 a.m., July 4. Emerged July 7. An intermediate male, on the under side resembling the wet-season form.

C2. Offspring of C. Egg laid April 26; hatched May 3; exposed to damp heat from 10 p.m., June 22, to 8 a.m., July 4; pupated 8 a.m., June 23; emerged July 8. An intermediate male, like C1, but somewhat more closely approaching the wet-season form on the upper surface.

C3. Offspring of C. Egg laid April 26; hatched May 3; pupated June 22; kept under normal conditions; emerged July 29. A male, intermediate on the

upper surface, but with the under side decidedly of the dry-season type.

- C4. Offspring of C. Egg laid April 26; hatched May 3; pupated June 28; kept under normal conditions; emerged Aug. 3. A dry-season female.

2. *Teracolus omphale*, Godt.

- D. A wet-season female (Figs. 7, 7a). Captured April 26, 1899. On the same day laid 19 eggs, which hatched on May 3. Seven of the resulting butterflies are in the Hope collection, as follows:—

- D1. Exposed to damp heat from 6 p.m., June 17, to 11 p.m., June 25; pupated 11 p.m., June 17; emerged June 27. A dry-season male, crippled.

- D2. Pupated 2 p.m., June 17; damp heat 6 p.m., June 17, to 11 p.m., June 25; emerged June 27. A yellow dry-season female, imperfectly expanded.

- D3. Damp heat 6 p.m., June 17, till emergence; pupated 8 p.m., June 17; emerged June 28. A yellow dry-season female.

- D4. Pupated 2 p.m., June 17; damp heat 6 p.m., June 17, to 11 p.m., June 25; emerged June 29. A dry-season male, not extreme.

- D5. Pupated June 10; normal conditions; emerged July 12. A white dry-season female, more advanced than D2 and D3; as shown by the diminution of the dark markings on the upper surface, and the disappearance of the transverse bar and orange-shaded discoidal spot on the under side of the hindwing, traces of these being visible in both the females D2 and D3, which had been exposed as pupæ to damp heat.

- D6. Pupated June 10; normal conditions; emerged July 14 (Figs. 8, 8a). A white dry-season female, still more advanced than D5.

- D7. Pupated June 16; normal conditions; emerged July 17. A dry-season male, more advanced than D4.

- E. A yellowish wet-season female. Captured April 30, 1899. Laid 15 eggs the same day. Offspring:—

- E1. Hatched May 8; pupated June 28; normal conditions; emerged July 25. A white dry-season female, with dark markings on disc of forewing greatly reduced, and with a yellowish shade re-

placing the orange in the centres of the apical interspaces. This is the specimen referred to by Mr. Marshall as E, No. 15 (p. 210).

E2 and 3. Hatched May 8; pupated June 28; normal conditions; emerged July 26. Two dry-season males.

F. A wet-season female. Captured May 3, 1899. Laid 2 eggs, which hatched on May 9. Offspring:—

F1. Pupated June 27; normal conditions; emerged July 26. A dry-season male.

F2. Pupated June 28; normal conditions; emerged July 26. A yellow dry-season female, not extreme.

G. A wet-season female. Captured May 10, 1899. Laid 10 eggs. Offspring:—

G1. Hatched May 18; reared under normal conditions; emerged July 31. A white dry-season female, not extreme.

G2. Hatched May 18; normal conditions; emerged Aug. 3. A dry-season male.

In all the above cases, the "dry-season" offspring of the parent *Teracolus omphale* corresponds generally with the form described by Mr. Trimen (South African Butterflies, vol. iii, 1889, p. 145) as *T. theogone*, Boisd. The specific identity of these two forms had long been suspected, and by the above series of specimens is placed absolutely beyond doubt.

In 1898 Mr. Marshall sent home a collection of butterflies from Salisbury, Mashonaland, which was described by Dr. Butler in Proc. Zool. Soc., 1898, pp. 902–912. In an accompanying letter to Dr. Butler he says: "I am somewhat in doubt as to the *Teracoli* I have sent you labelled *pallene*, for they are practically indistinguishable from the extreme dry form of *omphale*; yet the wet form is certainly not *omphale*, which I do not remember ever to have seen here, but seems referable to *pallene*." Dr. Butler (*loc. cit.*, p. 911) "has not the least doubt that these examples are ordinary *T. omphale*." An examination of similar specimens sent to the Hope collection by Mr. Marshall as *T. pallene*, led me independently to the same conclusion as Dr. Butler; and it is worthy of notice that while several of the bred examples just described are not separable from Mr. Marshall's specimens of *T. pallene*, the four parents, all of which were captured at Salisbury, are identified by Mr. Marshall himself as *T. omphale*. The inference seems

clear that there is no reason for considering Mr. Marshall's "*T. pallene*" from Mashonaland as specifically different from *T. omphale*.

It will be seen from the above descriptions that the damp heat to which many of the specimens of *T. omphale* were exposed was not entirely without effect; though the changes in the direction of the wet-season form are no doubt less marked than those produced in the case of *T. achine*, where the heat employed was greater.

3. *Teracolus phleggyas*, Butl.* (*T. difficilis*, E. M. Sharpe).

One specimen: Salisbury, Mashonaland. Larva suspended June 6, 1898; placed in damp forcer June 7; pupated same day; removed June 30; emerged June 31. An intermediate female, on the whole nearer to the dry than to the wet-season form. The dark markings on the upper surface of the forewings, including the discoidal spot, are, however, somewhat strongly developed for a dry-season form; and there is a well-defined grey basal patch, but no dark inner-marginal bar. Beneath, the hindwings have lost the definite spots of the wet-season phase, but have not assumed the dry-season colouring in its full development.

This completes the list of specimens of *Teracolus* mentioned by Mr. Marshall in his letters. The succeeding extracts bear reference to the African forms of the genus *Byblia*, Hübn.

"April 25, 1899.—I have a few authentic eggs of *Byblia ilithyia* and *acheloia*, which may perhaps decide the justice of Dixey's contention as to the specific validity of the latter.

"April 19, 1901.—I hope to be able to get some definite evidence as to *Byblia*, as I have now five pupæ and three larvæ bred from authenticated eggs of *ilithyia*, and one pupa and six larvæ from those of *vulgaris*, i. e. the wet-season form of *B. acheloia* (= *B. götzius*). The resulting butterflies will also prove the seasonal variation in the two forms. So far as my present material goes, I find that there is a very slight colour-distinction between the two larvæ in the last stage only.

"Sept. 27, 1901.—The specimens resulting from my damp experiments, together with those already sent, might

* This, though belonging to an earlier series of experiments, is inserted here for convenience

form the nucleus of a most interesting and instructive series to show the experimental evidence as to the proximate causes of seasonal dimorphism. . . . You will find some of the specimens from my *Byblia* experiments. The few that emerged all bred true to their parents, but the principal evidence consists in a slight, though constant, colour-distinction which I found in the larvæ of the two insects, thus proving them to be distinct species.”—G. A. K. M.

It is satisfactory to me to find that in consequence of his latest experiments, Mr. Marshall now holds the view as to the specific distinction between the two continental forms of *Byblia* which I felt justified in putting forward in 1898.* The specimens recently forwarded by him to the Hope collection from Salisbury, Mashonaland, are as follows:—

A. *B. ilithyia*, Drury. A worn wet-season female. Captured March 17, 1901. Laid 3 eggs. Offspring:—

A1. Hatched March 21; pupated April 11; emerged April 28. A wet-season female.

A2. Hatched March 21; pupated April 11; emerged April 29. An intermediate male.

B. *B. ilithyia*, Drury. A worn wet-season female (Fig. 1). Captured March 17, 1901. Laid 5 eggs. Offspring:—

B1. Egg laid March 24; hatched March 28; pupated April 11; emerged April 29. An intermediate male.

B2. Egg laid March 24; hatched March 28; pupated April 11; emerged April 30. An intermediate female (Fig. 2).

B3. Egg laid March 24; hatched March 28; pupated April 11; emerged May 1. An intermediate male.

C. *B. götzius*, Herbst. A worn wet-season female, of the form *vulgaris*, Staud. (Fig. 3). Captured March 24, 1901. Laid 6 eggs. Offspring:—

C1. Egg, March 24; hatched March 28; pupated April

* Proc. Zool. Soc., 1898, p. 376. The current number (Feb. 1902) of the “Entomologist’s Monthly Magazine” contains the first instalment of a paper by Mr. Marshall in which he gives a detailed account of his experiments in the breeding of *Byblia ilithyia* and *B. götzius*, with descriptions of larvæ and pupæ.

22; emerged May 8. A dry-season male, of the form *acheloia*, Wallgrn. (Fig. 4).

C2. Egg, March 24; hatched March 28; pupated April 24; emerged May 13. A dry-season male, like C1.

E. *B. ilithyia*, Drury. A wet-season female. Captured March 24, 1901. Laid 2 eggs. Offspring:—

E1. Egg, March 24; hatched March 28; pupated April 27; emerged May 19. An intermediate male.

These specimens supply complete proof, if proof were wanted, of the specific identity of *B. vulgaris*, Staud. with *B. acheloia*, Wallgrn., and also of *B. ilithyia*, Drury, with the African form corresponding to *B. simplex*, Butl., of India. It is to be noted that none of the bred *B. ilithyia* are of the full dry-season form. One or two of them, however, approach it so closely as to leave no manner of doubt that later in the year the typical "dry-season" colouring would be developed.

The following specimens of *Terias* sent home by Mr. Marshall are also worthy of note:—

Terias brigitta, Cram.

A. Malvern, Natal. Pupa in dry heat 6 days; emerged April 4, 1897. A wet-season male.

This is no doubt one of the two *T. brigitta* mentioned above (p. 205) as having withstood an amount of heat which proved fatal to *Acrwa cabira*.

B. Malvern, Natal. Pupa under normal conditions; emerged April 9, 1897. A wet-season female.

Terias senegalensis, Boisd.

A. Salisbury, Mashonaland. Captured April 7, 1901. (Figs. 9, 9a.) Laid 3 eggs. A wet-season female of *T. senegalensis*, Boisd. Offspring:—

A1. Egg laid April 7; hatched April 11; emerged June 10. (Figs. 10, 10a.) A dry-season male, of the form *T. æthiopica*, Trimen.

These two specimens are of great interest, as showing that a *T. hapale*-like form (*T. æthiopica*) may be bred from a *T. hecabe*-like parent (*T. senegalensis*); and as thus tending in some respects to confirm Mr. Marshall's view expressed to Dr. Butler in 1898 as follows:—

"You will notice among the *Terias* that I have pointed

out that *T. æthiopica* and *butleri* of Trimen are respectively dry and wet forms of the same species, and thus, taking the synonymy given in your revision, *hapale* must fall as a seasonal form of *senegalensis*. I have not actually proved the case by breeding, but I think you can take my observations on trust now."* I may mention that I had some time ago come independently to the conclusion that the *T. hapale* forms could not be specifically separated from the *T. senegalensis* assemblage, and had arranged the examples in the Hope collection in accordance with that view. But I do not think that even now the seasonal relations of these forms are quite clear.

In addition to the series just described, Mr. Marshall has also presented to the Hope collection the greater number of the specimens resulting from the experiments recorded by him in the "Annals and Magazine of Natural History," 1901, vol. ii, p. 398. They exemplify the very slight effect produced on the early dry-season broods by subjecting the larvæ and pupæ to conditions of moisture without heat. In Mr. Marshall's opinion, the amount of occasional inclination towards the wet-season form shown in this series is no more than might have been met with in examples of similar dates caught in the open. These specimens need no further notice here, having been fully dealt with by Mr. Marshall in his paper above referred to.

5. SUMMARY.

The main points of the present paper may be summarized as follows:—

1. *Catopsilia pomona*, Fabr. (including *C. catilla*, Cram.), and *C. crocale*, Cram. are phases of a single species. In at least one part of its range, these phases appear to be in relation with the seasons; in other parts there seems to be no such connection.

2. In like manner *Catopsilia pyranthe*, Linn. is conspecific with *C. gnoma*, Fabr. Here the association of each form with its own season is better recognized, but there is reason to think that even in this case the relation by no means obtains universally.

3. There are many other instances on record of the simultaneous occurrence in a given locality of forms of a

* Proc. Zool. Soc., 1898, p. 909.

species which are either known to be characteristic of the seasons in other parts of the range of the species, or which at least are analogous with proved cases of seasonal dimorphism.

4. Some of these cases of simultaneous occurrence are undoubtedly due to an overlapping at the change of seasons. In other instances the intermingling of the different forms takes place indifferently all the year round. This is perhaps more especially apt to occur in regions where the climate does not show very well-marked alternations between wet and dry.

5. Mr. Marshall has proved the specific identity of the following pairs of forms by actually breeding one from the other:—(a) *Teracolus topha*, Wallgr., and *T. auxo*, Luc.; (b) *Teracolus achine*, Cram., and *T. antevippe*, Boisd.; (c) *Teracolus omphale*, Godt., and *T. theogone*, Boisd.; (d) *Terias senegalensis*, Boisd., and *T. æthiopica*, Trim.; (e) *Byblia götzii*, Herbst (*vulgaris*, Staud.), and *B. acheloia*, Wallgrn.; (f) *Byblia ilithyia*, Drury, and the African form of *B. simplex*, Butl. In each of these cases it was already known that the different forms were respectively associated with different seasons, but the actual proof of specific identity afforded by “breeding through” had hitherto been wanting.

6. The final stage can in many cases be influenced by the artificial application of heat or moisture during the pupal condition. Thus, Mr. Marshall has found that dry warmth may cause the early wet-season form of *Byblia ilithyia* to approach the dry-season type of coloration; while the intermediate or early dry-season forms of *Pinacopteryx pigea* and *Crenis boisduvalii* were slightly affected in the same direction. Warmth in conjunction with moisture produced in early dry-season forms a tendency to revert to the garb of the rains. This was well seen in *Teracolus achine*, and to a less extent in *T. phlegyas* and *T. omphale*. On the other hand, neither the early wet-season form of *T. annæ* (1896), nor the early dry-season forms of several other species (1901) seem to have been affected by the application of moisture without the addition of heat, though a tendency towards the wet-season form made itself apparent under these conditions in *Pinacopteryx pigea* and, to a slighter extent, in *Crenis boisduvalii*.

7. Mr. Marshall has now detected constant differences in the respective larvæ and pupæ, which prove that *Byblia*

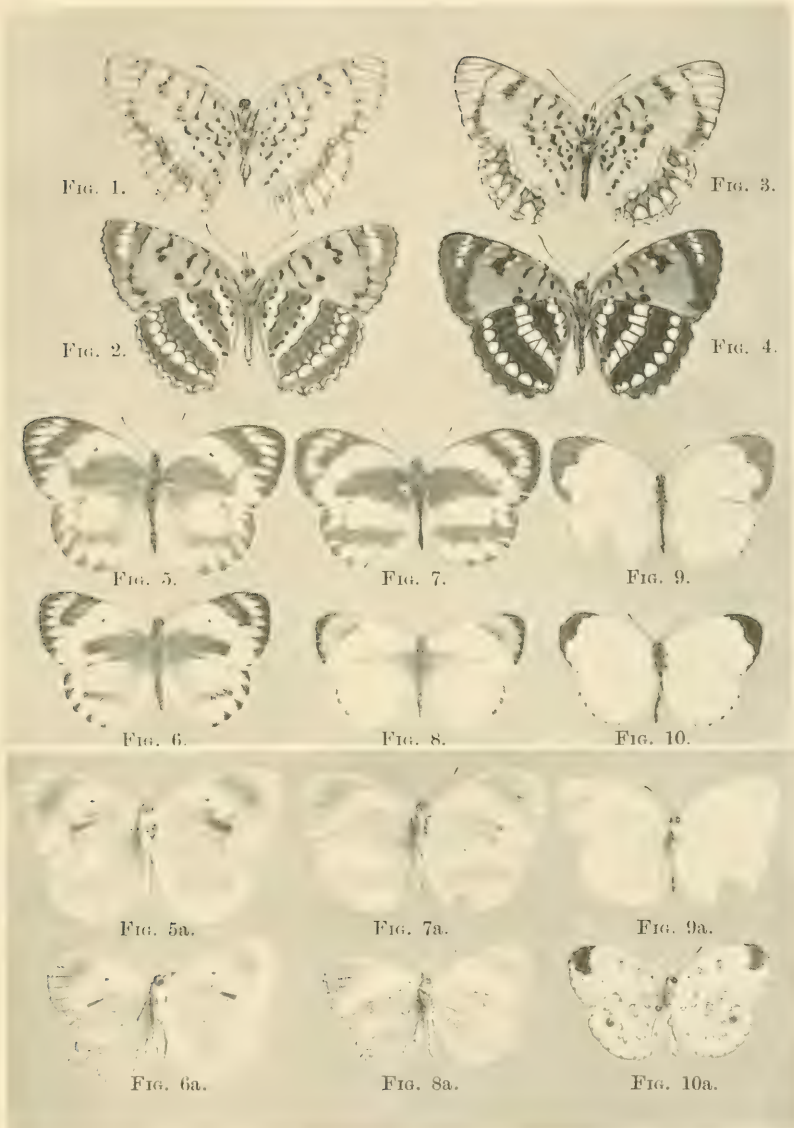
götzius (including *B. vulgaris*) is specifically distinct from *B. ilithyia*.

In conclusion, I wish to thank the authorities of the British Museum of Natural History, particularly Dr. Butler and Mr. Heron, for help that has always been courteously and readily given. My obligations to Professor Poulton are still more weighty; I owe to him the enjoyment of complete facilities for work in the Hope Department at Oxford, the loan of Mr. Marshall's letters, and the photographs of specimens that illustrate this paper. With regard to Mr. Marshall himself, I should wish to place on record my sense of the high value of his work as collector, experimenter and observer. He has had good opportunities, which he has known how to use in a thoroughly scientific manner. Moreover, what he has already achieved justifies us in looking for still greater results from his persevering labours.

EXPLANATION OF PLATE IV.

- Fig. 1 (underside). *Byblia ilithyia*, Drury. A wet-season female.
 2 (underside). Offspring of the above. An intermediate female, approaching the "dry" form which corresponds to the Indian *B. simplex*, Butl.
 3 (underside). *Byblia götzius*, Herbst. A wet-season female, of the form *vulgaris*, Staud.
 4 (underside). Offspring of the above. A dry-season male, of the form *acheloides*, Wallgrn.
 (See pages 214, 215.)
 5, 5*a* (underside). *Teracolus achine*, Cram. A wet-season female.
 6, 6*a* (underside). Offspring of the above. A dry-season female of the form described by Trimen as *anterippe*, Boisd.
 7, 7*a* (underside). *Teracolus omphale*, Godt. A wet-season female.
 8, 8*a* (underside). Offspring of the above. A dry-season female, of the form described by Trimen as *theogone*, Boisd.
 (See pages 210-211.)
 9, 9*a* (underside). *Terias senegalensis*, Boisd. A wet-season female.
 10, 10*a* (underside). Offspring of the above. A dry-season male, of the form *athiopica*, Trimen.
 (See page 215.)

In the actual specimens, owing to the presence of colour, the difference between the wet- and dry-season forms of the same species is more striking than appears in the Plate.



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All the figures are about $\frac{3}{4}$ of the natural size.

Seasonal Dimorphism in Butterflies.

- XVII. *Five Years' Observations and Experiments* (1896—1901) *on the Bionomics of South African Insects, chiefly directed to the Investigation of Mimicry and Warning Colours*, by GUY A. K. MARSHALL, F.Z.S. With a Discussion of the Results and Other Subjects suggested by them, by EDWARD B. POULTON, M.A., D.Sc., F.R.S., Hope Professor of Zoology in the University of Oxford, Fellow of Jesus College, Oxford; and an Appendix containing Descriptions of New Species by ERNEST E. AUSTEN, WILLIAM L. DISTANT, Colonel CHARLES T. BINGHAM, F.Z.S., GUY A. K. MARSHALL, and JULES BOURGEOIS.

[Read March 5, 1902.]

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I. INTRODUCTION.

A. BY GUY A. K. MARSHALL.

THE observations and experiments which form the groundwork of the present memoir were originally undertaken by me at the instance of Prof. Poulton, and such interest as they may possess is largely due to his valuable suggestions and advice. Moreover he has been good enough to undertake the entire clerical work in connection with the publication of the paper, and he alone is responsible for the numerous excellent plates with which it is illustrated. The utility of experiments such as here recorded depends almost entirely upon the manner in which the results may be treated. The mere accumulation of facts of this kind has little real value, unless these facts are properly classified and co-ordinated, and their bearing upon current theories adequately considered and discussed. This portion of the work has been left almost entirely in Prof. Poulton's hands, and I feel that I am fortunate in having obtained his hearty co-operation; for his wide experience in this particular line of research insures a thorough treatment of the subject.

In carrying out the experiments I have always endeavoured, so far as in me lay, to record the results as impartially as possible. But on reviewing my experiences as a whole I cannot escape the conclusion that they lend very strong support to the theories of Mimicry and Warning Colours as enunciated by Bates, Fritz Müller, and Wallace; I feel convinced that were naturalists more ready to carry out extensive experiments of this nature there would be much less of the prevalent *a priori* criticism of these valuable theories which throw light upon a vast number of facts which must otherwise remain for us mere meaningless coincidences. It is especially important that experiments should be made by as many different observers as possible, for in this way alone can the errors due to unavoidable personal bias be eliminated; and if the present publication only has the effect of inducing other entomologists in South Africa, or elsewhere, to turn their attention to the interesting problems involved, it will have fully served its purpose.

G. A. K. M.

B. BY E. B. POULTON.

The following memoir has been written upon and around the great mass of valuable material supplied by Mr. Guy A. K. Marshall's observations, experiments, and captures from 1896 to 1901. So far as this material consists of specimens it is open to the study and criticism of all naturalists; for it has been placed by the generosity of Mr. Marshall in the bionomic series of the Hope Department in the Oxford University Museum. The paper itself has been gradually growing during these years, not only by the accumulation of specimens, but by an uninterrupted correspondence between Mr. Marshall and myself. Extracts from Mr. Marshall's letters form a very important part of the whole work, and it is only right to point out that they were not written for publication, and that any want of co-ordination or continuity is entirely due to this cause. At the time when they were selected and arranged for publication there was no prospect of Mr. Marshall's return to England, and I was anxious that as many naturalists as possible might have the opportunity of reading the observations and discussions from which I had learnt so much and received such great pleasure; and when eventually he did return the paper had been read. Although no attempt was made to alter or re-write these extracts, Mr. Marshall's presence in England has made an immense difference in the work. We have been able to discuss the general arrangement and illustration as well as the details of many obscure and difficult subjects. On several points he has written paragraphs which give a far higher value to the paper. Where the experience of the naturalist on the spot has been specially required it has become available. The sections of the paper under my own name have also greatly benefited by his kind assistance, and the opportunity of discussing points of special difficulty or uncertainty. It will be clear to all who read the paper that Mr. Marshall and I do not entirely agree in the interpretation of many facts, especially those connected with the seasonal phases of *Pieris*, and in the extent and predominance of Müllerian mimicry as compared with Batesian in Lepidoptera. For these and other reasons it is necessary to state explicitly that I am solely responsible

for the opinions and considerations set forth in the sections to the titles of which the initials "E. B. P." are appended (in both the contents and the text). Mr. Marshall's numerous and important contributions to these sections are always acknowledged and placed between inverted commas. The titles of Mr. Marshall's sections are indicated by the initials "G. A. K. M.," and my contributions to these are always placed between square brackets, and are furthermore indicated by my initials.

Colonel J. W. Yerbury has kindly contributed one section and Colonel C. T. Bingham another, and both have given much help in other parts of the work. Some of the most strange and interesting insects were undescribed species, and would have been comparatively valueless for the purpose of this memoir, were it not for the kind assistance of the naturalists who have written the Appendix. Dr. F. A. Dixey kindly read the proofs and made many valuable suggestions and corrections. Mr. C. J. Gahan has given much kind assistance in the sections dealing with Coleoptera and in the identification of species. The number of species sent by Mr. Marshall is so large that the work of identification has been very laborious and prolonged, and we desire warmly to thank Sir George Hampson and the whole of the staff of the Insect Department of the British Museum, every one of whom has been consulted at one time or another. We also wish to thank heartily Colonel C. T. Bingham, who has named the whole of the Hymenoptera; Colonel J. W. Yerbury, who has worked out the majority of the Diptera; Mr. M. Jacoby, who has named many Phytophaga; Monsieur Jules Bourgeois, who has named the *Lycidæ*, and Mr. W. L. Distant, who has named the Hemiptera. Much other kind assistance has been given and is acknowledged in the text of the work.

Valuable material with excellent data, comparing in a most interesting manner with that sent by Mr. Marshall, was contributed from British East Africa by my kind friends Mr. and Mrs. S. L. Hinde.

The thirteen uncoloured plates are reproduced from excellent negatives taken from the actual specimens by Mr. Alfred Robinson in the Oxford University Museum. The two coloured plates are reproduced from Mr. Horace Knight's drawings of the specimens.

A brief abstract of some of the chief results here recorded

in detail was communicated to the Zoological Section of the British Association at Bradford (Report 1900, pp. 793-4), and an abstract of the present paper is printed in the Proceedings of the meeting at which it was read (Proc. Ent. Soc. Lond., 1902, pp. x-xiii). Some of the observations were also brought before the International Zoological Congress at Berlin, 1901 (Verhandlung, p. 171). Lists of the specimens presented to the Hope Department and a brief statement of the principles which they illustrate have been published yearly in the "Report of the Hope Professor of Zoology" communicated to the "Oxford University Gazette." Allusion to some of the material and the problems it illustrates, has also been made by the present writer in Linn. Soc. Journ. Zool., vol. xxvi, 1898, p. 558, and Report Brit. Assoc., 1897, p. 689. Much has been written upon the work on seasonal dimorphism in the genus *Præcis*, but full references will be found in this section of the present paper.

The first part of the following work, occupying just half of it, deals with experiments and observations upon insectivorous animals, and the conclusions and considerations arising out of this work. The experiments on *Mantidæ*, Kestrels, and baboons will be found to be especially numerous and important. A table shows all the examples of *Asilidæ* and the species forming their prey which could be found recorded or preserved in the British Museum and Hope Collection. The direct and indirect evidence of the attacks of birds on butterflies meets objections which are often raised, and indeed nearly the whole of this part of the paper is an effective reply to those who ask for facts rather than hypotheses. One very important side of the work is the employment of Coleoptera on a large scale, and the clear evidence of aposematic and synaposematic colours in the group. A comparison between the Coleoptera and Lepidoptera in this respect is attempted. The first half of the memoir ends with a section discussing and criticizing the conclusion that there is any great significance or value in human experience of the taste and smell of insects.

The second half of the work is more heterogeneous. Its first section attempts to supply an interpretation of the startling seasonal phases of butterflies of the genus *Præcis*. In this section Dr. A. G. Butler's convenient

terms "wet phase" and "dry phase" * are generally used in preference to "form" or "variety," while Mr. Marshall's useful sign \oplus to indicate the former and \ominus to indicate the latter are freely employed. The remainder of the paper is chiefly devoted to the description of an immense mass of material illustrating mimicry and common warning colours in Rhopalocera, Coleoptera, Hymenoptera, and to a less extent Hemiptera. Many interesting conclusions emerge and are discussed.

I entirely agree with Mr. Marshall's opinion that an unbiassed consideration of the facts presented in this paper yields a very strong measure of support to the classical theories of Bates, Wallace and Fritz Müller. I would go further and maintain that Mr. Marshall's observations and experiments here recorded, place Africa in the first position as the region which supplies stronger evidence than any other of the validity of these theories. But I am even more impressed by the strong support yielded to the modern developments of Fritz Müller's theory of mimicry. Where has Professor Meldola's Müllerian explanation in 1882 of the common facies of specially-protected sub-families of butterflies received such illustration as in the groups of synaposematic *Acræinæ* captured in one place and at one time; or the extension in 1887 by the present writer of the same interpretation to the types of insect colour and pattern which are common to a country, received such support as in the marvellous group of Mashonaland insects of many Orders with an appearance founded upon that of the distasteful Coleopterous genus, *Lycus*? And the most recent developments of all, the discovery (1894-7) of the principle of "reciprocal mimicry" or "diaposematic resemblance," and of the specially close mimetic resemblance of the females in Müllerian mimicry no less than in Batesian by Dr. Dixey, together with his Müllerian interpretation of resemblances between mimics overlying their resemblance to a common model, all these, founded on the study of Neotropical forms, have supplied the explanation of numerous instances in the Ethiopian Region although applied to very different families and

* The term "phase" is advantageous inasmuch as it is conveniently applicable to the whole of the winter or summer generations of a species, as well as to single individuals of either seasonal form.

sub-families of butterflies, to Coleoptera as well as to Lepidoptera.

I cannot conclude without warmly thanking my friend Mr. Marshall for the pleasure I have enjoyed in the work which we have done together.

E. B. P.

2. EXPERIMENTS ON MANTIDÆ IN NATAL AND RHODESIA.
(G. A. K. M.) *Natal, February 1897.*

I. Gave a wingless *Acræa horta* to a Mantis. It seized it and threw it away. On a second presentation it felt the butterfly carefully with its antennæ, then took it and began eating first the haustellum, then the palpi, and finally the whole head with apparent relish. On biting at the thorax, however, it threw it down with evident disgust and began wiping its mouth on its fore-legs as though to take away the taste. I again presented the butterfly, but the Mantis at first only ran away from it. At last it took it again and began eating the thorax, but quickly threw it down and would have nothing more to do with it.

II. Experiment *a*.—Caught a full-grown Mantis and put it in a large green gauze bag. In the afternoon put in a house-fly, which was not eaten that day, but was gone next morning. Then put in a wingless male *A. horta* (a bitter yellow juice exuded from the wing stumps). On perceiving it the Mantis ran towards it, seized it and made a bite at the back of the thorax, but started back as if in great surprise, and wiped his mouth on his front legs. He exhibited both fear and curiosity; for as the *Acræa* approached he edged away, just keeping far enough off to be able to touch it with the end of his long antennæ, and when the *Acræa* walked away he followed, still feeling it over. At this point I was called away, and on my return found that the *Acræa* had been eaten all except the head and apical half of the abdomen. Afterwards put into the bag the *Amauris echeria* which had been rejected by spider C (Experiment 13), and which was half dead. As the Mantis took no notice of it I left, but on inspection in the evening I found that this butterfly had been entirely devoured, only a few small fragments of wings and legs being left.

Experiment *b*.—Gave the Mantis a perfect male *A.*

horta. He tackled it at once, seizing it from above and biting the thorax, but he quickly let go and began wiping his mouth as before. A few minutes later he made a second attempt with the same result. After this he appeared to avoid it. I then put in a wingless *Amauris ccheria* and left him for some time. On my return I found it had been entirely eaten, whereas the *A. horta* was still untouched. Took the *horta* out, cut off its wings and replaced it. The Mantis eyed it with suspicion whenever it came near him, and felt it cautiously with his antennæ; when it came too near him, he backed away and would not attempt to touch it. Later on I tapped the gauze so that the *horta* fell close by the Mantis. He gripped it at once, and began eating away at the underside of the abdomen, but soon threw it down again, and would not touch it although I gave him no other food for twenty-four hours. After that I put in a male *Belenois severina*, which he devoured readily.

Experiment *c*.—After starving the Mantis for twenty-four hours I gave him a *L. chrysippus*. On seeing it fluttering he came down to it eagerly and soon caught it. The large wings prevented him for some time from getting at the body, and he therefore ate away almost half a hind-wing. He then went on and ate the whole insect except the limbs.

Experiment *d*.—Gave the Mantis a *Papilio demodocus*. He had some difficulty in catching it at first, owing to its size and strength, but eventually seized it from below and devoured it.

Experiment *e*.—Gave an entire female *horta* to my captive Mantis. He caught it, bit the thorax and started back with disgust, just as in the previous experiment, but his efforts to get rid of the nasty taste were more prolonged. For over five minutes he continued cleaning his mouth on his fore-legs or rubbing it from side to side on the gauze. I then put in an entire *Amauris ccheria*, but he seemed too scared to attempt to touch it. However, he caught it during the night (while there was a light in the room) and ate all the abdomen, leaving the head and thorax.

EXPERIMENTS ON *Mantidæ* AT MALVERN, NATAL.

III. On March 11, 1897, I captured a large female green Mantis [probably *Polyspilota caffra* (Westw.) or very

near it]. On the 12th I gave her an *A. petraea*, which she devoured entirely. On the 13th I gave her an *A. serena*; she seized it and ate a good piece out of one of the hind-wings. She then attacked the thorax, but after a few bites threw down the insect and began ejecting a brownish liquid from her mouth on to a leaf, and also wiped her mouth with her legs in the usual manner. A few moments after I put in a male *Hypolimnas misippus*, which she soon caught and ate. Later on I put in another *A. serena*, but she paid no attention to it. I then put in a *P. demodocus*, with the same result, so I removed them both. On the 14th I gave her no food. On the 15th I put in one *A. encedon* and one female *H. misippus*, but no attention was paid to either. I eventually removed *encedon*, leaving *misippus*. Later on put in *Eurytela hiarbas*, and left both in all night and through the next day, but the Mantis would not touch them. As it was beginning to show signs of weakness I released it.

IV. Experiment *a*.—March 25. Caught another female Mantis [probably the same species as the last], and gave her an *A. cabira*, which she quickly caught. She began by eating part of the fore-wing, but as she reached the base of the costa dropped it suddenly. A little later, while I was not watching, she took it up again and ate all the body except the head and anal segment. I then gave her a *Charaxes varanes* and a *P. demodocus*, which were both eaten immediately in succession.

Experiment *b*.—March 26. Gave the Mantis an *A. cabira*. The day being cloudy and cool, she was sluggish, and it was some time before the butterfly was caught. She missed the first two strokes, catching it at the third and eating it entirely.

Experiment *c*.—March 27. Gave one *A. encedon* to Mantis. It immediately flew right on to her, which seemed to frighten her considerably, and she did not attempt to catch it, but edged away when it approached. This continued for a quarter of an hour, so I took the *encedon* out and put in a *P. demodocus*, which was soon caught and eaten. Later on I put in a *Neptis agatha*; the Mantis seemed rather suspicious of it, but eventually caught and ate it. I then gave her a *Pentila tropicalis*, which she ate, including the whole of the two fore-wings. I then tried her again with the same specimen I had given her in the morning; she caught and ate it without

any signs of distaste. Subsequently gave her *Mylothris agathina*, which was also eaten.

Experiment *d.*—March 28. I gave a male *A. serena* to Mantis. After a few moments she caught it and ate a bit out of the wings, but soon threw it down. The butterfly at once walked straight back to her and was promptly caught again, and after a single bite was again rejected. On looking a few hours afterwards I found it had been eaten. I then gave her a *P. tropicalis* and an *Alæna amazoula*, both of which were eaten, the latter wings and all.

Experiment *e.*—March 29. I gave Mantis one *Eurytela hiarbas*, one *Pyrameis cardui*, one *Junonia clelia*. All were eaten.

Experiment *f.*—March 30. I put one male *A. serena*, one *P. demodocus*, one *N. agatha*, and one *P. tropicalis* into the Mantis' cage at the same time. They were caught and eaten in the order mentioned without any sign of distaste. Immediately after she had finished I put in a brilliant dark-blue moth with orange markings (*Egybolis vaillantina*), which has a strong smell. To my surprise she completely demolished it, and then ate a second *P. demodocus*.

Experiment *g.*—March 31. Gave Mantis a *P. demodocus* in the morning, which she ate: in the afternoon gave her one *L. chrysippus*, which she ate without any ado, and immediately afterwards a female *H. misippus*. I then gave her an *Acræa natalica*, which she quickly seized, but on biting the thorax dropped it at once. For some time she paid no attention to it, but later on tried it again, biting a little out of the wings and then dropping it again; after which she had nothing more to do with it. Subsequently put in a *Papilio brasidas*, which was promptly eaten.

Experiment *h.*—April 1. In the morning gave Mantis an *A. serena*. She caught it, and after eating the apex of one fore-wing threw it down, but a few seconds after she caught it again, nibbled a bit out of the costa of fore-wing and again threw it down. After a short interval the butterfly walked past her, she seized it, bit at the thorax and at once rejected it. A few moments later she made a fourth attempt, this time eating half an antenna, but again found the taste too much for her. I then removed the butterfly and put in an *A. encedon*, but after nibbling a

small bit out of the wing she would have nothing more to do with it. In the afternoon I tried her with an *A. cabira*, which she also refused; I removed it and put in one *J. clelia* and one *P. brasidas*, but apparently the continued disappointments she had undergone disheartened her, for she would have nothing to do with either of them, but avoided them, and only tried to escape through the glass of the cage. About an hour after she ate the *brasidas*, but had not touched the *clelia* by sundown.

Experiment *i*.—For three days I fed the Mantis only on clearly edible species. On April 5, after eating two *P. demodocus* I gave her *L. chrysippus*, which she soon caught, but after eating a small portion of a hind-wing, she threw it down. A few seconds after, however, she caught and consumed all except the wings. She then ate a male *H. misippus*, and immediately after I put in a male and female *A. cabira*. The male was eaten at once; she then caught the female and ate a piece of the wing, but threw it down after the first bite at the thorax. The butterfly remained for a long time at the bottom of the box feigning death, so I put in another *L. chrysippus*. The movements of the latter disturbed the *cabira*, which was promptly seized by the Mantis, the abdomen being eaten but the thorax rejected. Shortly afterwards the *chrysippus* was caught and eaten from head to tail. Next morning as a sequel to this feast I found the Mantis in an apparently half-dead condition. The abdomen was much distended and no fæces had been passed for twenty-four hours. I therefore gave it no food whatever for two days. On the third day it seemed better and fæces were passed freely, but it still seemed very weak and refused food. Next day I found that it had lost all power of gripping with its fore-legs, so I fed it by hand on edible species. This I continued to do for several days, but it never properly recovered its strength, so I killed it.

V. EXPERIMENTS ON *Pseudocreobotra wahlbergi*, Stål.

1897.

Sept. 3. Lower Umkomaas River. Captured a male *P. wahlbergi*, and gave him an *Acraea cabira*; he nibbled a bit out of the wings, then ate the whole abdomen, but on

reaching the thorax rejected it, the butterfly having still sufficient vitality to flutter about.

- Sept. 4. In the morning gave him an *M. safitza*, which he ate at once. In the afternoon put in an *Acræa cucedon*, which he seized twice, but on eating a bit of the wing rejected; however, towards evening it was eaten.
- „ 5. Gave him an *Acræa serena*; he seemed frightened at first and avoided it, but ate it about an hour afterwards. Put in another later, which remained untouched.
- „ 6. The *serena* of yesterday was left uneaten all the morning. I therefore removed it and put in an *A. cabira*, which was also refused.
- „ 7. In the morning removed the *cabira*, and put in another *serena*. As the *Pseudocercobotra* had not eaten it towards evening, I gave him an *M. safitza* in addition. He seemed to detect the difference, watching it immediately it was put in, and as soon as it came within striking distance, he seized and ate it, but still paid no attention to the *serena*.
- „ 8. The *serena* remained uneaten all day, though from its appearance it had evidently been seized. In the afternoon put in a *Neptis agatha*. The Mantis avoided it at first just like the *Acræa*, but about an hour later I found it had been eaten.
- „ 9-11. Wet days and no *Acræas* procurable.
- „ 12. Gave Mantis an *M. safitza* and an *A. serena* at the same time; he seemed very frightened of both, avoiding them, or else striking at them in order to drive them away. Some hours later I found the *safitza* had been eaten entirely and a small piece out of the abdomen of the *Acræa*, which, however, was still quite lively.
- „ 13. Gave Mantis two *A. serena* during the day, both of which were seized at once and eaten entirely from head to tail without any sign of distaste.

- Sept. 15. Put in an *A. serena*. It was eaten after a short interval. Later gave him an *A. encedon*. At first he seemed only frightened, but subsequently caught it, and after taking a bite at the thorax threw it down and paid no further attention to it.
- „ 16. Brought *Pseudocreobotra* from Umkomaas to Malvern.
- „ 18. Put a *Teracolus omphale* and an *A. encedon* into his box, but they were not touched all day, owing to their inactivity and the large size of the box. The Mantis was also more sluggish in its movements than in a natural state.
- „ 19. Caught the *encedon* and offered it to Mantis in my fingers. He objected strongly at first, but eventually took a small nibble but would not try another bite. Offered him the *omphale* in the same way, but being suspicious he refused it also, but at last took a bite, and, finding it all right, ate it all. On again putting the *encedon* near his mouth he only felt it with his palpi but would not eat.
- „ 20. Left the same *encedon* in all day in hopes that he might be compelled to eat it by hunger ; but he did not do so.
- „ 21. *Encedon* untouched, so removed it and put *Pseudocreobotra* into a smaller box with the specimens of *A. serena*, but he seemed to take no interest in them. On holding one of the butterflies to his mouth, he felt it persistently with his palpi and seemed almost as though he were trying to eat but could not. He was certainly weaker on his legs.
- „ 22. One of the *encedon* died during the night, and in the course of the morning I found the Mantis apparently eating at its head as it lay at the bottom of the box, without using his fore-legs, which were held out on each side. However, on taking up the butterfly I found he had made no impression on it. I then placed a *Terias brigitta*

close to his mouth, and he mumbled at it in the same manner without eating. It therefore seemed evident that his mandibles must have been paralyzed in some way, and on examination this proved to be the case, for they could be moved easily with a pin backwards and forwards, the insect clearly having no control over them whatever. The grip of the fore-legs though noticeably weaker than normal was not completely lost, as in the previous experiment with a "Charaxes-eating" Mantis. I am inclined to think that the insect became at last partially blind, both from its actions and from the appearance of a small discoloured patch in the left eye, a symptom which also occurred in the "Charaxes-eating" Mantis.

The results of Experiment VI. practically negative the supposition that any of the above symptoms might be due to *insufficient* food.

VI. EXPERIMENTS ON LEAF MANTIS (*Phyllocrania insignis*, Westwood).

[One of Mr. Marshall's specimens was compared with the type of the above-named species in the Hope Collection.]

At the Lower Umkomaas River, during September, I kept two specimens of this insect for twelve and fourteen days respectively without a particle of food, and neither their vitality nor activity were in any way impaired at the end of that period. When captured they were in their pupal instar, and the final change took place on the 10th and 7th days respectively, both insects casting their skins in a normal and healthy manner in spite of their long fast.

VII. EXPERIMENTS ON "CHARAXES-EATING" MANTIS (*Polyspilota caffra*, Westwood, or very near this species).

1897.

Sept. 23. Caught, at Malvern, Natal, a "Charaxes-eating" Mantis (in the pupal stage), and gave him a *T. achine* and an *Acræa*

serena at the same time. He was somewhat wild at first, paying no attention to them but only trying to escape. Eventually he took the *achine* from my fingers and ate it, and later caught and ate the *Acræa*.

- Sept. 24. Mantis ate a *Belenois severina*.
 „ 25. Mantis ate two *Acræa enceldon* without showing any signs of distaste.
 „ 26. Gave him two *A. enceldon*, but they were not eaten.
 „ 27. Mantis ate one *enceldon*.
 „ 28. The second *enceldon* dead. Put in four *Pardopsis punctatissima*, but no notice was taken of them.
 „ 29. Mantis still refused to eat. Two *P. punctatissima* dead. Put in one *A. enceldon*.
 „ 30. One more *P. punctatissima* dead, and the remaining one was three-parts eaten, the *enceldon* being left.
- Oct. 1. Gave Mantis one *P. punctatissima* and one *A. serena* in addition, but he made no attempt to catch any of them, even when they settled quite close, merely feeling towards them with his antennæ; if they came too near he only ran away or else drove them off by striking out straight with his fore-legs. The discoloured patch in the left eye made its appearance on this day, and the sight on that side was evidently somewhat impaired. The legs also seemed to be weakening, and the grip of the front pair was not so strong as in normal specimens.
- „ 2. No butterflies eaten, though I tried several times. I think that he may have been preparing for the final change of skin, which would account for his refusal to eat.
- „ 3. Mantis attempted to perform the final ecdysis during the night, but owing to his bad state of health could not free himself properly from the old skin, being permanently deformed in a doubled-up

attitude when I first looked at him. I therefore killed him.

Judging from Experiment VI. the inability to change can hardly be attributed to weakness caused by want of food.

[In relation to the above-recorded experiments it is important to know the habits and natural food of the Mantis, and if possible to determine the species. Mr. Marshall kindly sent a specimen of an identical, or at any rate very closely-allied species, together with the following notes.—E. B. P.]

“*Umkomaas Mouth, Natal; Sept. 3, 1897.*—The Malvern species of Mantis is one of the largest out here, and I selected it as I knew it to be almost entirely a butterfly feeder. It frequents chiefly Acacias and their allies, and catches the *Charaxes* which come to suck the gum. Unfortunately they are scarce at Malvern, and I could not procure a single specimen during the winter, for I had hoped to make the very experiment you suggest, viz. feeding exclusively on *Acraeas* or *L. chrysippus*. However, I caught two small Mantises on my arrival here (Umkomaas Mouth) yesterday, but I have not as yet even seen an *Acraea*.”

“*Malvern, Oct. 7, 1897.*—I am not quite certain whether the *Charaxes*-eating Mantis sent is specifically identical with the one that died from *Acraea* diet. I thought it was the same in the pupal stage, but the imago of the latter has the upper wings entirely green, with a small yellowish spot about the middle. Unfortunately I have not been able to get one.”

[The Mantis sent (captured at Malvern, Sept. 1897) was *Polyspilota caffra* (Westwood), of which the type is in the Hope Collection, Oxford.—E. B. P.]

VIII. EXPERIMENTS WITH *Pseudocreobotra wahlbergi*, Stål, female.

1897.

- Sept. 26. I captured at Malvern a full-grown female Ocellated Mantis, which ate a specimen of *Acraea encedon* during the day.
- „ 27. Gave Mantis two *A. encedon*. She ate the thorax of one, rejecting the remainder.
- „ 28. The remaining *encedon* died to-day. Removed it, and put in one *Acraea neobule*

- and five *Pardopsis punctatissima*, but the Mantis would not touch any of them.
- Sept. 29. Mantis still refused to eat, one *P. punctatissima* dead.
- „ 30. Three more *punctatissima* dead. Mantis ate the *ncobule* entirely.
- Oct. 1. The remaining *punctatissima* dead. Put in two *Acræa encedon* and one *A. serena*. The Mantis seemed more keenly alive to their presence than usual, eagerly following them in their flight with sharp turns of the head like a cat watching a swallow. At last the *serena* gave her a chance, and was immediately seized and eaten. No more were eaten during the day, and towards evening I put in another *A. serena*.
- „ 2. The day being dull the three butterflies were quite inactive. I therefore placed the *serena* near the Mantis, which soon seized it, and ate nearly the whole of one fore-wing and part of the other; finding this unsatisfactory she dropped it. I then offered her an *encedon*, which was promptly taken and devoured entire, and immediately afterwards the *serena* was eaten.
- „ 3. Wet day: no *Acræas* procurable. Remaining *encedon* dead.
- „ 4. Gave Mantis two *A. encedon*. She was evidently hungry, on two occasions making futile jumps towards the butterflies as they fluttered past, instead of waiting for them to come within striking distance; there was however a noticeable decrease in her general vivacity. Eventually she caught both butterflies in quick succession, and devoured them completely. After the head of the second one was eaten, a large drop of yellow liquid oozed from the thorax. On tasting it she drew back quickly and seemed uncertain whether to go on or not, but finally put her mouth to it and sucked it all up,

though it appeared to me as if it were done under protest.

- Oct. 5-6. No *Acræas* procurable.
- „ 7. Put four *P. punctatissima* into her box at the same time. During the short time I was watching I saw her catch one or other of them no less than *seven* times, but on each occasion after the first nibble or two she threw it down with evident disgust.
- „ 8. I was absent all day, but all the butterflies had evidently been further attacked by the Mantis, and small pieces had been eaten out of the fore-wings, but in no case had the bodies been damaged.
- „ 9. Removed all the *punctatissima* and put in two *A. cabira* and one *A. encedon*, which were consumed entirely in quick succession. The Mantis appeared to show no decided symptoms of ill-health at present. I was unable to complete the experiment.

IX. FIRST EXPERIMENT WITH MANTIS. SALISBURY.

1898.

- March 2. Caught a pair of large green Mantis *in copulâ* [*Sphodromantis lincola*, Burm.].
- „ 3. Gave them one *A. caldarena*, one *A. halali*, and one *A. neobule*, but they were all untouched.
- „ 4. The *caldarena* had been caught and discarded, the thorax and one wing being partly eaten; removed the butterflies.
- „ 5. Female Mantis ate the male. Put in two *caldarena* and one *induna*; Mantis tasted one of the former but quickly threw it down. During the day the other two were evidently caught and tasted, as they were both more or less damaged about the head and thorax.
- „ 6. Mantis ate one *caldarena* and the *induna*; remaining *caldarena* died from injuries.
- „ 7. Put in three *caldarena*, one of which was partially eaten.

- March 8. One other *caldarena* completely eaten; the third died, its head having been partly eaten.
- „ 9. Put in one female *halali* and one male, and one female *caldarena*. The former was soon caught, but after a few bites was rejected with evident disgust.
- „ 10. Male *caldarena* eaten completely, female partially.
- „ 12. Put in male *natulica*, one male and one female *caldarena*; the two former partially eaten. The latter was caught three times in quick succession, but promptly rejected on each occasion after the first bite.
- „ 13. Put in a male *halali*, which the Mantis took at once, throwing it away after eating about half the thorax. Then gave her a male *caldarena*, which was completely eaten, so put in a second, which she promptly caught, but threw it down after the first bite at the thorax. She caught it again about a minute afterwards and started eating the apex of abdomen, but two bites were sufficient. A third attempt ended similarly.
- „ 14. Saw Mantis seize and reject the same *caldarena* twice; removed it in the evening.
- „ 16. Put in a male *caldarena*, which was completely eaten, but a second which I gave her immediately afterwards remained untouched. The Mantis began to show distinct signs of weakness, and I observed an opaque blackish spot in her left eye to-day for the first time.
- „ 17. The male *caldarena* was killed to-day by a bite on the head. Mantis began to nibble off the end of one of her front tarsi, a sign that her end is not far off.
- „ 18. Gave her a female *caldarena*, which was caught several times but not eaten. She continued to nibble at her tarsi.
- „ 19. Mantis oviposited during the night, but the egg cocoon was only half as large as usual in this species [eggs proved to be infertile].

Gave her one male *halali* and two male *caldarena*. They were all caught in succession, but she only ate a very small piece out of each. At times she seemed very frightened of them, and in running away she twice fell upon her back, when she had some difficulty in righting herself owing to weakness.

- March 20. Put in three male *caldarena*, one of which was caught and the whole of one forewing and part of the thorax eaten.
- „ 21. Remaining two butterflies untouched. Mantis had by now eaten off the ends of all her tarsi except the anterior and intermediate on one side.
- „ 22. In the afternoon I found the Mantis dead on her back.

X. SECOND EXPERIMENT WITH MANTIS. SALISBURY.

1898.

- March 19. Caught a large green female Mantis of same species as previous one [*Sphodromantis lincola*, Burm.], and gave her one *Junonia cebrene* and three *Terias senegalensis*, all of which she ate. She also ate the following:—
- „ 20. One *T. senegalensis*, one *T. brigitta*, one *Belenois severina*.
- „ 21. One *J. cebrene*, one *Catochrysops osiris*.
- „ 22. Two *Alæna amazoula*, without showing any signs of distaste.
- „ 23. One *Spinulasis natalensis*, two *J. cebrene*.
- „ 24. One *T. senegalensis*, two *Myrina ficedula*.
- „ 25. The Mantis escaped from the box this morning, and I did not find her till 5.30 p.m., when she was busy ovipositing on the side of a book. She had then laid about a third of her eggs, and did not stop laying till 8.30 p.m.
- „ 26. Mantis ate one *Parosmodes icteria*, and two *Hesperia spio*. She seemed very hungry, following the butterflies about instead of waiting for them to come within striking distance.

- March 27. She ate one *Catopsilia florella*; I then put in a *Belenois mesentina*, and she became much excited, running about after it, and making several futile snatches at it on the wing. At last she gave a vigorous stroke, and missing the butterfly caught the gauze with which the box was covered. Imagining apparently that she had caught her prey, she began trying to eat the gauze, in spite of my attempts to drive her away, for fully two or three minutes. At last she desisted and soon caught and devoured the butterfly, eating a *B. severina* and *Axiocerces harpae* immediately afterwards.
- „ 28. One *Precis sesamus* and one *B. mesentina*.
- „ 29. One *Hamanumida davidulus* and one *B. severina*.
- „ 30. One *Pyrameis cardui* and one *B. mesentina*.
- „ 31. One *J. cebreus* and two *B. severina*.
- April 1. One *J. cebreus* and one *C. florella*.
- „ 2. Two *C. florella* and one *P. cardui*.
- „ 3. Mantis escaped. She was fully as vigorous and healthy on the last day as when first caught.

XI. THIRD EXPERIMENT WITH MANTIS. SALISBURY.

1898.

- April 3. Captured a female Mantis closely allied to those of preceding experiments, being of same size and colouring, but having a much broader thorax and the mouth pink. This insect I submitted to a purely distasteful diet, combined with periods of starvation, as follows:—
- „ 4. Three *Acræa caldarena* eaten.
- „ 6. Two „ „ „
- „ 7. Two „ *axina* „
- „ 8. One „ *caldarena* „
- „ 9. Two *Limnas chrysippus* „
- „ 10. One „ „ „
- „ 11. One „ „ „
- „ 12. One „ „ „

- April 16. One *Limnas chrysippus* eaten.
 „ 20. One „ „ „ ; then left
 her a month entirely without food, which
 however did not seem to affect the
 health or vitality in any way.
- May 19. One *Acræa axina* eaten.
 „ 22. One *L. chrysippus* „
 June 4. One „ „ „
 „ 5. Two „ „ „ This insect never
 once exhibited the least signs of distaste
 for any of the butterflies, and devoured
 them all with avidity, showing a marked
 contrast to the Mantis first experimented
 with (IX.), which throughout exhibited
 an intense dislike to the *Acræas*, and
 evidently ate them from sheer hunger.
- The close proximity of these two kinds of
 Mantis suggests the idea that they might
 possibly be seasonal forms of one species
 in which the winter form has adapted
 itself to an *Acræa* diet, owing to the com-
 parative scarcity of other butterflies at
 that season. In spite of its diet and long
 fast, this Mantis was still fully as vigorous
 and healthy as when first captured.
- „ 30. Ate one *L. chrysippus*.
 July 8. Gave it two *Acræa axina* ; it tasted both of
 them several times, but in every case at
 once discarded them with evident disgust.
 „ 22. Gave it two more *A. axina* with precisely the
 same result.
- Aug. 21. Ate one *L. chrysippus*.
 „ 22. „ „ „ „
 „ 28. „ „ „ „
 „ 29. „ two „ „
 Sept. 4. Put in one *L. chrysippus*. The Mantis
 showed its normal eagerness, and followed
 it about for some time, finally attempting
 to seize it, but failed. The vigorous
 flutterings of the butterfly seemed to
 frighten the Mantis, which ran away
 from it and made no further attempt to
 catch it.
- „ 5. Put in two more *chrysippus*, but Mantis

was still scared and would not go near them.

- Sept. 8. Mantis died. There were no signs of ill-health as in former experiments, and the characteristic blotch in the eye was absent. Death was probably due either to hunger or natural causes. I only wonder at its lasting so long, considering its long fast and unhealthy food.

[The above experiments upon Mantidæ of four different genera are summarized as follows:—

Mantis I., in the Karkloof. Evident intense dislike, after trial, of *Acræa horta*.

Mantis II., male, in the Karkloof. Evident dislike of *A. horta*, although one specimen out of three was almost entirely eaten. Two *A. echeria* were eaten, and one partially. One *L. chrysippus*, one *B. severina*, and one *P. demodocus* were eaten.

Mantis III., female, probably *Polyspilota caffra*, at Malvern. Ate one *A. petraea*, but rejected *A. serena* after trial. Ate one male *H. misippus*, but after this refused all butterflies, and exhibited signs of weakness.

Mantis IV., female, probably the same species, at Malvern. Ate *Papilio*s and *Nymphaliniæ* freely, including the probably aposematic genus *Neptis*, and the probably aposematic Lycænid genera *Alena* and *Pentila*, and Pierine genus *Mylothris*. Ate *L. chrysippus* with hesitation, and partially in one case, freely in two cases. Hence the Mantis appeared to be a very general feeder on all butterflies except the genus *Acræa*, the species of which (*cabira*, *serena*, *encedon*) were rarely eaten until after one or more trials, and were sometimes finally refused. *Natalica* was only offered once, and rejected after trial. It is interesting to note that immediately after trial of three different *Acræas*, the Mantis refused species which she freely ate at other times. The final weakness without power of recovery was a probable result of the diet.

Mantis V., male, *Pseudocreobotra wahlbergi*, on the Lower Umkomaas River. Ate *M. sajitzæ*, *T. omphale*, and *Neptis agatha* freely, the first-named on three occasions. *Acræa cabira*, refused twice; *encedon*, refused twice after trial and accepted once; *serena*, refused on five occasions, eaten on four. It is probable that the weakness and loss of sight was due to the *Acræa* diet.

Mantis VI., *Phyllocrania insignis*, on the Lower Umkomas River. The evidence that starvation for twelve and fourteen days respectively does not produce the symptoms observed in Experiments III., IV., V., VII., and IX.

Mantis VII., male, in pupal stage, probably *Polyspilota caffra*, at Malvern. The Pierines *P. achine* and *B. severina* freely eaten. Of the Acreas, two *encedon* eaten apparently freely, and one after an interval, others refused: one *serena* eaten after a time: of four *punctatissima* only one partly eaten. The Mantis then refused all food, became weak, and one eye was affected. He was unable to throw off the pupal skin properly. In Experiment VI. two individuals of another species performed this change of skin after ten and seven days of starvation.

Mantis VIII., female, *Pseudocreobotra wahlbergi*, at Malvern. Only offered Acreas. Nine *punctatissima* always refused with or without trial; *encedon* eaten freely several times, refused once, and partly eaten once; two *cabira* eaten freely; *serena* eaten freely or after trial; *neobule* eaten after two days' interval.

In spite of this diet the Mantis remained apparently healthy, September 26 to October 9, 1897, when the experiment came to an end.

Mantis IX., female, *Sphodromantis lincola*, at Salisbury. It was intended to offer this individual a purely Acrea diet, but she ate her mate on the third day after their capture *in copulâ*. She was chiefly fed upon Acrea *caldarena*, which she ate sometimes freely, sometimes after an interval and after trials: at other times she refused it with or without trial; one *induna* was eaten after a day's interval; one *neobule* was untouched; one *natalica* was partly eaten; two *halali* were rejected after trial, one without. After a fortnight of this diet the Mantis became weak, and her left eye was affected: a day later she began to nibble off the end of one of her fore tarsi: two days later she oviposited, but the egg cocoon was only half its usual size (eggs infertile). After the first signs of weakness the Mantis ate only a small part of three Acreas out of eight offered her during six days. She continued to nibble at her tarsi, lost power over her movements, and died after twenty days of captivity.

Mantis X., female, *Sphodromantis lincola*, Salisbury. This individual was the subject of a control experiment, being fed solely upon several species of the following groups

—*Nymphalinae*, *Pierinae*, *Lycanidae*, and *Hesperidae*. The only species with marked aposematic colouring and habits was the Lycenid *Alana amazoula*, and of this only two specimens were offered, both being eaten freely. After fifteen days of this diet the Mantis escaped: she was then as healthy and vigorous as when first captured.

Mantis XI., female, species resembling *Sphodromantis lincola*, Salisbury. Fed solely upon *Acræa caldarena* and *A. axina*, and *Limnas chrysippus*, with long periods of starvation, two of them a month in duration. Seventeen *chrysippus*, six *caldarena*, and three *axina* were eaten without any signs of distaste, while four *axina* were discarded after tasting several times. The Mantis was captured on April 3, 1898, and refused food on September 4, dying on September 8 without signs of ill-health or blindness. Mr. Marshall suggests that the species may be a winter form (possibly of *S. lincola*) specially adapted to eat *Acræas* when other butterflies are scarce.—E. B. P.]

3. CONCLUSIONS FROM EXPERIMENTS ON MANTIDÆ. (E. B. P.)

Certain conclusions stand out very clearly, while others are suggested as probable. These voracious insects did not show any dislike of butterflies outside the *Danainæ* and *Acræinæ*. The undoubtedly aposematic Pierine genus *Mylothris* was freely eaten, and so were the following genera with probable warning colours, movements, and attitudes—*Neptis*, *Alana*, *Pentila*, and the moth *Egybolis vaillantina*. Even the *Danainæ* were generally eaten without hesitation (II., IV., XI.), and never rejected altogether. In marked contrast was the behaviour of *Mantidæ* towards *Acræinæ*, which were constantly refused, and often eaten only after one or more trials and long intervals of time. When the *Acræas* were eaten freely and without hesitation there is reason for suspecting exceptional hunger. The summary of experiments shows very clearly that "*Pardopsis* appears to be considerably more distasteful. . . . than the general run of *Acræas*" (G. A. K. M., October 7, 1897, Malvern). There were also less marked differences in the degree of dislike shown towards other species; thus *axina* was less freely eaten than *caldarena* (XI.); *caldarena* appeared to be eaten more freely than *halali*, *neobule*, *induna*, and *natalica*.

(IX.), although the number offered of these latter was insufficient to warrant a certain conclusion; *cabira* was rejected while a considerable proportion of the *enchedon* and *serena* were accepted (V.); *horta* evidently possesses a high degree of unpalatability to *Mantidæ* (I, II.).

Mr. Marshall's evidence, by far the most important collected in the case of the *Mantidæ*, is in entire accord with the few observations which had been previously recorded. Thus the late Mr. de Nicéville found that *Acræa violæ* was the only butterfly refused by all the species of *Mantis* with which he experimented in the East ("Butterflies of India, Burmah, and Ceylon," vol. i, pt. ii, p. 318). Colonel J. W. Yerbury informs me that he watched the Mantis *Gongylus gongyloides* hanging from the drooping lavender flowers of a species of *Duranta* at Trinkomali (1890-91), and capturing the butterflies which were attracted by the bloom. The insect hung by its four posterior legs, with head thrown back and predaceous legs held ready for striking. He saw it capture and eat *Delias eucharis* on several occasions, and also *Belenois mscutina* and the Hesperid *Hasora alexis* (Fab.). Colonel C. T. Bingham has also given me a male specimen of the Harpagid Mantis, *Cerobotra urbana* (Fab.), found by him on a Lantana bush actually eating *Delias descombesi* (Boisd.). This observation was made in the North Shan States, Upper Burma, on October 9, 1900. The fact that two species of *Delias* were thus freely eaten compares in an interesting manner with the acceptance of *Mylothris* by the African species of *Mantis*. We may safely conclude that outside the *Acræinæ*, and doubtfully the *Danainæ*, *Mantidæ* devour butterflies very freely, the species with warning colours as well as the others, and that they are far more indiscriminating than the majority of vertebrate insect-eaters. Thus Mr. F. Finn found *Delias eucharis* to be one of the most distasteful of all butterflies to many species of Indian birds ("Journ. Asiat. Soc. Beng.," vol. lxvii, Pl. ii, No. 4, 1897, p. 667). Mr. Finn also found in East Africa that a moth of the genus *Egybolis* (*E. vaillantina*) was refused by a Chamæleon and a Gecko ("Natural Science," vol i, No. 10, Dec. 1892, p. 747). It is of deep interest to find such marked differences between the preferences of the various groups of insect-eating animals.

In addition to the observations recorded above, Dr.

David Sharp, F.R.S., quotes Mr. F. Muir concerning the food of *Idolium diabolicum* (Sauss.) at Mozambique :—"Its food seemed to consist of flies, *Limnas chrysippus* being rejected, even when hungry, and other butterflies only taken for lack of other food" (Proc. Cambr. Phil. Soc., vol. x, pt. iii, p. 175). Mr. Edward Barlow (Proc. Asiat. Soc. Bengal, Dec. 1894) states that *Hierodula bipapilla* (Serv.), kept in captivity at Calcutta, ate ordinary flies (*Musca* sp.) with avidity, but attacked with great reluctance the common large green blowfly (*Lucilia* sp.), only eating them when they could get nothing else. Two bugs, *Cyclopetia* sp. and *Physomerus* sp., offered when the Mantis was very hungry were never eaten, although often killed. After tasting the former, the Mantis wiped its mouth against its right fore-leg several times. This last observation is the only record I have found of Hemiptera offered as food to *Mantidæ*.

The question arises as to whether the preferences exhibited by *Mantidæ* in captivity are the same as those which exist in the wild state. A Mantis is probably less affected in this respect by confinement than a vertebrate animal; but the same general criticism will probably hold in both cases—that while the rejection of an insect by a not over-fed insectivorous animal in captivity is evidence of unpalatability or dislike, its acceptance is not sufficient evidence of appreciation or that it constitutes an element of the normal diet. An insect may be eaten readily in captivity which would be rejected or only eaten under the stress of hunger in the wild state; for it is generally quite impossible to supply an animal under artificial conditions with the variety and often the quantity of insects which it would catch for itself. In this respect a large Mantis can be kept in a more normal condition than an insectivorous vertebrate, because of the much larger amount of food required by the latter; although the young Mantis would offer great difficulties to the breeder, because of the vast numbers of very minute insects which it would require. But Mr. Marshall's experiments yielded plenty of evidence of the positive refusal and acceptance, as it were under protest, of *Acræwinæ*, so that there can be no doubt of their distastefulness to this class of enemy, although acceptance might under the circumstances have not been convincing proof of their palatability. It is however in every way satisfactory to obtain evidence

from the behaviour of *Mantidæ* in the wild state, and such as we do possess entirely confirms the conclusions to be drawn from Mr. Marshall's experiments. In the first place we have the following observation of his own, made in the Karkloof, Natal, in February 1897 :—

“Saw a Mantis catch a male *horta* on a flower in the veldt. It began eating at the base of the abdomen, which it consumed entirely, and then started on the thorax, of which it only ate a very little, and then threw it away.”

This observation corresponds almost precisely with many made upon the captive insects. Mr. Roland Trimen also says that he never found the wings of *Danaïs* or *Acræa* among the fragments of butterflies which sprinkle the ground below the feeding-place of a large Mantis, although he is careful to add that he could not be sure that these butterflies visited the exudations of Acacia sap, round which the predaceous insects secure a plentiful supply of food (Linn. Soc. Trans., vol. xxvi, 1870, p. 500). It has already been pointed out that Colonel Verbury's and Colonel Bingham's observations upon *Mantidæ* in the wild state are entirely confirmatory of Mr. Marshall's observations of them in captivity, as regards the food which appears to be freely provided by certain Pierine genera refused or disliked by other insect-eating animals.

Another question of deep interest raised by Mr. Marshall's experiments on *Mantidæ* is the inquiry how far the species which they reject or eat only sparingly is unwholesome or even poisonous to them. There is strong *à priori* probability for the view that the preferential appetite of such a form as a Mantis is merely the strong instinctive tendency to eat the food which best suits its organization and reject that which suits it least. We should expect therefore that such marked disinclination to eat *Acræas* as we observe in *Mantidæ* indicates, not distaste or unpalatability in an anthropomorphic sense, but merely that *Acræas* are unwholesome to *Mantidæ*. The evidence requires to be sifted in detail.

In Experiment III. the signs of weakness seem to be a too-excessive result of the single *Acræa*, and portion of another, which were eaten. At the same time generic and specific differences are almost certainly of great importance, and it must be remembered that III., IV., and VII. belonged to probably the same species, and all exhibited weakness after an *Acræa* diet, resulting in the death of

IV., the deformity of VII., while III. was released. Experiments V. and VIII. were also upon the same species of Mantis. The first, a male, became weak and probably blind after eating a few *Acræas*; the second, a female, remained apparently healthy after an exclusively *Acræine* diet for fourteen days. It is very unfortunate that this latter experiment could not be continued. It is, however, clear that in the case of this species and sex a purely *Acræine* diet for fourteen days is not necessarily unwholesome. Experiments IX., X., and XI. were upon species which were the same, or nearly the same, and all females. The first died after an *Acræa* diet for twenty days, the second was perfectly healthy after a mixed butterfly diet without *Acræinæ* and *Danainæ* for fifteen days, while the third lived healthily from April 3 to September 8 upon *Acræas* and *Limnas chrysippus*. The latter seems to be an insuperable difficulty, but it must be remembered (1) that *chrysippus* was given in especially large numbers, and there is no evidence that *Danainæ* are much rejected by *Mantidæ*, (2) that the Mantis may have recovered from the effect of the *Acræas* during the long fasts, (3) that the *Acræa* chiefly made use of, *A. caldarena*, may be less unwholesome than the majority of the group.

More experiments are greatly wanted, but Mr. Marshall's observations render it highly probable that *Acræas* are unwholesome to *Mantidæ*. The definiteness of the symptoms exhibited, and especially the effect upon the eye, constitute not unimportant evidence in support of this conclusion. The appearance of an opaque blotch in the left eye of three of the Mantises (V., VII., IX.) suggests further experiments in order to test whether we have to do with mere coincidence or a phenomenon of deeper significance.

Mr. Marshall's conclusions from his experiments were written upon the results obtained with spiders as well as Mantises, and will be found at the end of the section upon the former (p. 322).

4. EXPERIMENTS ON SPIDERS IN THE KARKLOOF.

(G. A. K. M.) *Natal, February 1897.*

[The Rev. O. Pickard-Cambridge, F.R.S., informs me that the species made use of was the common and widely-distributed Epeirid *Nephilengys malabarensis*, Walck.—E. B. P.]

The spiders experimented on were all of one species with very large females and minute males. Their webs were all round the verandah, where they were strictly preserved by Mr. Ball. I never saw the species in the bush.

1. Gave a spider (A) a specimen of *Acræa horta* (entire); she ran down and bit the thorax, then pulled it out of the web and dropped it. At the same time gave *A. horta* with its wings cut off to another spider (C) of the same species, which ate it without hesitation.

2. Gave *horta* without wings to four spiders (A, B, D, and E), and also one in which half the wings had been cut off to C. All were eaten readily.

3. Gave entire males of *horta* to A and B, and both were at once rejected.

4. Wingless specimens of *L. chrysippus* given to A and C were at once thrown out of their webs.

5. The following wingless specimens were given to this species:—*Papilio brasidas* to A, *P. ophidicephalus* to B, *P. euphranor* to C, *P. ophidicephalus* to D, *Eurytela hiarbas* to E, and *P. lyæus* to F. All of them were promptly eaten.

6. Caught a female *horta*, rubbed all the colour off its wings, leaving them entire, and gave it to A, which after careful examination wrapped it up and carried it off to eat.

7. Gave A a perfect male *horta*; she ran down and bit it in the thorax and ejected it from the web. I then rubbed all the colour off the wings and returned it. The spider approached it carefully feeling round with her palpi, and again cut the butterfly loose. I then gave it to B, which also refused it. I then cut the wings off and gave it to B again, with the same result. Finally I gave it to A again, but she pulled it out of the web by the abdomen and dropped it.

8. Gave wingless specimens of *Papilio demodocus* to B and C. Both were eaten.

9. Gave a perfect female *horta* to D, which bit it several times, being seemingly rather doubtful about it, but eventually wrapped it up and carried it off to her chamber. After a short time she threw it down, the butterfly being still alive.

10. On two occasions saw dead specimens of *A. horta* in spiders' webs in the bush. They were both wrapped up, but evidently had not been sucked.

11. Cut off the wings of three male *horta* and gave them to A, B, and C, but they were all rejected. Gave one of the same specimens to D, which carried it off to eat, and was still sucking it when observed two and a half hours afterwards.

12. Gave a wingless *Amauris echeria* to A, which came down very cautiously and bit it in the thorax as usual. Its taste was evidently unpleasant, as in extricating the butterfly from the web it carefully abstained from biting any part of the body. I then put the same specimen in B's web; she ran down at once and tackled it. After giving it a few bites she paused as though in doubt, then, as if thinking it was worth trying, she wrapped it up and drew it up after her to her chamber. She was clearly still doubtful, as she remained several minutes without attempting to touch it. She then sucked it for a few seconds, but soon let it drop. Gave the same specimen to D, and it was rejected. Gave another wingless specimen to C, which also was rejected.

13. Gave entire specimens of *Terias brigitta* to B, C, and D, and also female *Nepheronia argia* (*agathina* form) to A. All were eaten readily. Subsequently gave entire *P. sesamus* (*natalensis* form) to C, which was also eaten.

14. Gave a perfect male *horta* to D. She ran down, bit it in the thorax as usual, wrapped it up and carried it off. She then remained some minutes without attempting to touch it, then after sucking it for a few seconds she threw it away. (Compare Experiments 9 and 11.)

15. Gave a wingless *Acræa violarum* to spiders B, C, and D, in succession. It was promptly ejected by each of them.

16. Gave entire specimens of *A. horta* to spiders A, B, C, and D. The two former ejected theirs at once; C cut hers loose from the web, and was holding it in her jaws preparatory to throwing it away, when she seemed suddenly to change her mind and ran up to her chamber with it, without however enshrouding it with web. She remained with it in her mouth for about half a minute, and then threw it down. D took no notice whatever of the insect in her web.

17. Gave male *Acræa buxtoni* to A, and female *Nepheronia argia* (*agathina* form) to C. Both were eaten.

18. Gave *Pontia hellica* to B, *Papilio demodocus* to C, and

Planema csebria to D. All of them were eaten, though D seemed a little suspicious at first.

19. Gave *Byblia goetzius-acheloia* to A, which ate it readily, although she was a long time before coming down to see what it was.

20. Gave wingless specimens of *A. horta* to spiders A, B, C, and D (six days since last were given—Experiment 16). The first three promptly ejected them, but D wrapped hers up and carried it off. She did not seem very enthusiastic about it however, for she turned it over and over a good many times, giving it a bite here and there, and then left it alone for some time. This procedure she repeated several times, and then threw it away.

21. Gave entire males of *Acrva serena-buxtoni* to spiders A, C, and D, all of which were eaten. It should be noted that experiments with this species are unsatisfactory, owing to the fact that when captured it is able voluntarily to exude from the thorax its bitter yellow juice, and therefore when given to spiders it has lost much of its nauseous quality, and would be less distasteful than if caught by them direct.

5. RESULTS OF EXPERIMENTS ON SPIDERS AND THE EARLIER EXPERIMENTS ON MANTIDÆ: ONE PROBABLE MEANING OF TENACITY OF LIFE IN DISTASTEFUL INSECTS. (G. A. K. M.)

Malvern, Natal; February 21, 1897.—The danger of arguing from insufficient materials was clearly shown me in my first few experiments on spiders with *A. horta* (Experiments 1, 2, 3, and 6). When I had got thus far I felt sure I had got proofs of the appreciation of warning colours by the spiders. For in these experiments they ate every specimen without wings and refused all those with them except one which had the colour rubbed off. Yet subsequent experiments have convinced me that both spiders and Mantises have no appreciation of warning colours; and this fact has elucidated another which often puzzled me, I mean the apparently constant correlation between distastefulness and tenacity of life in Lepidoptera. At first sight it would seem that tenacity of life or the power to recover after severe injury would be useful to any species in the struggle for existence. But a little thought showed me that this power would be of no use to edible species, as if once caught by insectivorous animals

they are not likely to be released. But in the case of inedible species it is different. For if my surmise is true, that insectivorous invertebrates are not capable of appreciating warning colours but have to taste *all* their captives before being able to tell whether they are edible or not (which I think is clear from my experiments), then tenacity of life (as a protective agency) will be as useful an acquisition against invertebrates as warning coloration is against vertebrates, and come into play when the latter is useless. Of course tenacity is of use against the experimental tasting of young birds, lizards etc., but this does not seem to me to be a sufficiently cogent factor to develop the power to such a high pitch. For if the insects had only these enemies to contend against, even supposing every specimen experimentally tasted died from its injuries, the protection afforded by the warning colours would still be ample. Indeed I believe that the toughness of inedible insects has been primarily developed to counteract the injuries from invertebrate foes (which are incapable of reasoning as to whether an insect is edible or not), and that therein lies its chief utility, though it may prove useful incidentally in other cases.

A. buxtoni appears to have more juice in proportion than *horta*, and I regard it as a more highly-developed species, from a distasteful point of view, in that it can exude juice at will from its thorax, and thus show its nauseous qualities without necessarily having to be injured like *horta*. When squeezed the juice often oozes from the ends of the antennæ and all the nervures of the fore-wings when they are cut. But, as I have pointed out (*vide* Expt. 21), the results of experiments with it are unreliable.

The treatment of *A. horta* by the spiders would almost give some colour to your suggestion that the inedibility of species may be due to unpleasant internal effects rather than the mere taste, for B ate one specimen and A, C, and D two each before they seemed to become aware that it was not good to eat, from which I should conclude either that the unpleasant effects are subsequent to eating or that their sense of taste is not sufficiently acute to recognize a nasty flavour at once. But the latter conclusion appears to be invalidated by their prompt rejection of *L. chrysippus* and *A. echeria*. Anyway their selection seems to show that there are grades of unpleasantness, and, as I

expected, those species in which the sexes are alike are least edible. Thus I expect to find that *A. anemosa*, *A. cabira*, and *P. aganice* will prove more distasteful than their allies in which the sexes differ markedly. However, I must admit that in the case of the Mantis this was not so, and its persistent preference for *echeria* rather than *horta* (on three occasions) is very curious and interesting. Its dislike of the taste of *horta* was most marked, and yet it did not appear to distinguish it by sight. In Experiment II. c (p. 298) the Mantis certainly avoided *horta* after its first taste, but it showed equal fear of *echeria*, which it afterwards ate, and I presume could not distinguish between them. But it is clear that it was unable to retain long the impression which connected a butterfly with an unpleasant taste. The prompt acceptance of *A. serena* by the spiders appears to support my view that the bright red colour conveys no significance to them, although they find the red *horta* distasteful. I was surprised at their unanimous refusal of the single specimen of *A. violarum* I was able to procure, as I had thought it would certainly be more edible than *horta*, and I am almost inclined to believe that it was rejected under a misapprehension.

I had an idea that perhaps *Papilio demodocus* was distasteful, which was suggested by its wide range and general abundance; and that if this were so it would be probable *P. ophidicephalus*, *P. euphranor*, *P. constantinus*, etc., might obtain protection from their strong resemblance to it on the wing. But my experiments seem to negative the idea as far as invertebrate foes are concerned.

Again, *Terias* has always puzzled me. They are so widely distributed and always plentiful; moreover, their flight is weak and their contrasting colours of black and yellow are most conspicuous on the open veldt, which they frequent; indeed, far more so than the colours of the females of *A. violarum* and *nohara*. Yet they do not seem to be protected, although some of the tropical *Durbanias* and *Teriomimæ* appear to mimic them.

Malecræ, Natal; Oct. 7, 1897.—The experiments on the effects of an *Acræa* diet, so far as they go, seem to lend some measure of support to your view as to the unwholesome qualities of *Acræa*, though many more experiments will be necessary to establish it. If I could only get the material I should like to experiment contemporaneously on a number of the same species, starving one,

giving one or two only edible butterflies, and confining the remainder to a single species of *Acrwa* or *Amauris* each. But at present I find it not only difficult to get hold of a Mantis, but it is even quite a job to catch sufficient *Acræas* to continue the experiments. I have not seen a single specimen of *A. petraea* for over six weeks, though normally it should be swarming at this time of year.

[Mr. Marshall subsequently carried out a part of the programme which he here suggests. See Experiments IX., X., XI. on *Mantidæ*.]

When the experiments on spiders are compared with those on Mantises the conclusion is suggested that *Acræinæ* were distasteful to both, and only eaten under the stress of hunger, while *Danaïinæ* were far less distasteful to the Mantises than to the spiders. To the latter they appeared to be at least as distasteful as the *Acræinæ*. Such differences in the susceptibilities of insect-eaters help us to understand the puzzling case of *Terias*, and the Ethiopian Lycanid genera which appear undoubtedly to mimic it, and permit us still to look on *Papilio demodocus* as a possible model. We see that the various insectivorous groups have different tastes, and within each group we must expect to find individual species adapted to feed largely on insects which are as a rule rejected by the other members of the same group.

In one respect spiders are extremely satisfactory for the purpose of these experiments. They remain throughout wild animals with their natural sources of food still available. The same may be the case with Mantides, as in the *Gongylus* watched day after day by Col. Yerbury at Trinkomali (see p. 316).

The late Thomas Belt ("Naturalist in Nicaragua," London, 1888, p. 317) states that a "spider that frequented flowers seemed to be fond of" the *Heliconidæ* (including *Ithomiinæ*), although a large species of *Nephila* used to drop them out of its web when he put them into it.

Dr. A. G. Butler (Trans. Ent. Soc. Lond., 1869, p. 27) long ago showed that the larvæ of *Abraças grossulariata* and *Halia waxaria* were not eaten by the spiders he employed—*Epeira diadema* (the name given in the paper is *Ereiba diadema*) and *Lycosa* species (?). In the former case they were cut out of the web, and in the latter seized and carried down the "dark silken funnel," but then relinquished apparently uninjured. Professor Plateau (Mém.

de la Soc. Zool. de France, tome vii, 1894, p. 375) gives reasons for doubting whether the latter spider belonged to the genus named by Dr. Butler, and he supposes from the described form of "funnel" that the "*Lycosa*," which does not make a web, was in reality *Agelena labyrinthica*. Professor Plateau's fresh experiments (l. c. § 8) on spiders, however, entirely confirm the results obtained by Dr. Butler so far as the larva of *Abraxas* is concerned. An *Amurobius ferox*, which had spun a characteristic web in captivity, paid no attention during two days to three half-grown larvæ moving about and entangled in the web. From the Professor's long experience of spiders in captivity he is confident that it was not afraid, and he thinks it probable that it refrained from attack because the vibration of the web was not like that caused by its habitual prey. It would have been more satisfactory if this interpretation had been tested by the offer of a few inconspicuous larvæ. In the next experiment four larvæ were thrown into a large web spun by a female *Tegenaria domestica* over the roof-light of a barn in such a position that the observer could watch everything without in the least disturbing the spider. The following is a translation of Professor Plateau's account:—"At the moment of the fall of the larvæ into the web, the *Tegenaria* . . . rushes at one of them and bites it, or at least makes two successive attempts to bite it. The spider then leaves the first victim and attacks a second, which she also tries to bite, but the skin of the larvæ being too tough and the caterpillars rolled up and pretending to be dead, she retires *slowly*, a certain proof to those who know the habits of these animals that she does not feel any fear." Afterwards, when the caterpillar began to move the web, the spider, "having learnt the uselessness of her attempts to bite, neglects them entirely and remains in her tube."

Concerning this and the previous interpretation, it is necessary to remark that no signs of fear were to be expected upon the hypothesis that the spider recognized that the larva was uneatable; while the suggestion that the skin was too tough to be penetrated seems to be very improbable.

An experiment of the same kind was then made with a female *Tegenaria*, which spun a web in confinement. After keeping the spider for three days without food, two caterpillars were thrown into the web. The spider rushed

towards one of them but retreated again, "recognizing that it had been disturbed by a creature such as had never before fallen into the web." The same thing was again repeated on four occasions, the spider never actually attacking a caterpillar. *Agelena labyrinthica* was then tried in the same way, but would not leave its retreat; when, however, an earwig was substituted for the larva, it was instantly seized and devoured.

On the other hand, Professor Plateau has produced evidence that the imago of the *Abraaxas* is freely eaten by *Tegenaria domestica*. Nearly every day for some weeks he placed this moth, sometimes on one, sometimes on another of three or four webs of this spider spun in a little tool-house in his garden. They were always seized and carried off.

Agelena labyrinthica, on the other hand, killed the moth but abandoned it after some attempts to suck its juices. Professor Plateau suggests that the spider found the prey too large for it, an interpretation which might have been advanced had the attempt to capture and kill been unsuccessful; but, as the case stands, serves to show that the author is willing to accept any explanation however improbable rather than the obvious one that there was something in the taste or smell of the moth which prevented the spider from devouring it.

A half-grown female *Epeira diadema* devoured the moth with avidity. It is to be hoped that this experiment will be repeated many times, as in the case of the *Tegenaria*; and in all such researches comparison should be constantly made with the behaviour of the spiders towards many other kinds of insects.

It is quite probable from the experiments of Mr. Marshall and Professor Plateau, and the observations of the late Mr. T. Belt, that certain species of spiders, together with Mantides and other predaceous insects, will be found to be among the chief, perhaps the chief, non-parasitic enemies of aposematic insects.

Colonel J. W. Yerbury has kindly searched his notes for any references to the attacks of spiders on butterflies. He writes, "I can find very few references to the relations of these two animals to each other in my old notes. The following are two of them:—

"*Aden*, ? date.—A large green flower-haunting spider resting on a dried-up plant was preying on a female

Teracolus vi. The specimen was almost the first female of the species which I obtained. The individuals of this butterfly roosted regularly on the stalks of the plant in question, their under-sides being of about the same tint as the dried-up leaves and stems.

“*Futchpore Sikri, near Agra, May 1877.*—Spiders lay in wait for the Pierine *Belenois mesentina*, on the flowers of a caper (*Capparis aphylla*). On this occasion the spiders took a very heavy toll of the butterflies.”*

[Mr. C. J. M. Gordon has sent to the Hope Department a male specimen of *Acræa bonasia*, which he found on January 8, 1902, at Old Calabar, in the grasp of a flower-haunting spider (*Thomisus*, sp.). The fangs of the arachnid were fixed in the butterfly's thorax, and the insect was nearly dead.—E. B. P.]

6. THE ATTACKS OF PREDACEOUS INSECTS OTHER THAN MANTIDÆ UPON CONSPICUOUS SPECIALLY-DEFENDED LEPIDOPTERA, ETC. (E. B. P.)

H. W. Bates, in the historic paper which contained the first suggestion of the theory of Protective Mimicry (Trans. Linn. Soc., vol. xxiii, 1862, p. 495), states concerning the attacks of predaceous insects: “I never saw the flocks of slow-flying *Heliconidæ* [in the writings of Bates and Belt upon Mimicry, the *Heliconidæ* always include the *Ithomiinæ* or *Neotropinæ*, then called the *Danaoid Heliconidæ*] in the woods persecuted by birds or Dragonflies, to which they would have been an easy prey; nor, when at rest on leaves, did they appear to be molested by Lizards or the predaceous Flies of the family *Asilidæ*, which were very often seen pouncing on Butterflies of other families” (p. 510).

There is, however, good reason for believing that such attacks are not rarely made, and that predaceous insects are important enemies of aposematic butterflies.

In the following three sub-sections of this paper I have brought together some slight evidence in support of this conclusion. Far more requires to be done, and it is hoped that the attention which is here directed to the inquiry

* Shortly after I had made the observation I came across a reference to this habit of the spiders at the very same place, but I cannot now recall the name of the publication.—J. W. Y.

may bring the subject to the notice of naturalists, especially in the parts of the world where the struggle for existence is keenest.

A. Predaceous Hymenoptera and Neuroptera.

The Neuroptera are included here and not under a separate heading because I have as yet only received a single record, and that one in association with an observation on predaceous Hymenoptera. Accurate observations on Odonata and *Mantispidæ* are greatly needed, as well as on the predaceous Hemiptera. Large *Tenthredinidæ* should also be observed, for I have seen them devouring insects. *Locustidæ* furthermore are considerable and indiscriminate enemies of their class. I have seen them eating Acridians, and there is a specimen of one in the Hope Department together with its victim, a moth.

The late Thomas Belt long ago recorded the capture of Nicaraguan "*Heliconidæ*" by a yellow and black banded wasp for the purpose of storing its nest: "Whenever one of these came about, they would rise fluttering in the air, where they were safe, as I never saw the wasp attack them on the wing. It would hawk round the groups of shrubs, trying to pounce on one unawares; but their natural dread of this foe made it rather difficult to do so. When it did catch one, it would quietly bite off its wings, roll it up into a ball, and fly off with it" ("*Naturalist in Nicaragua*," Lond., 1888, p. 109). The following observation of Mr. Marshall's upon the chief unpalatable butterfly of the Old World compares in an interesting manner with the foregoing:—

"*Tugela River, junction with Blaauwkrantz River, Dec. 14, 1896.*—I have observed two enemies of *Limnas chrysippus* lately: one is a large wasp which I saw carrying off the larvæ, and the other was a very large red dragonfly which was devouring an imago." It is quite likely that the Odonata may not uncommonly attack such conspicuous butterflies, but this is the only record I have as yet received.

Experiments and observations on ants suggest an almost boundless field of inquiry. The following interesting observation made by my friend Mr. C. J. M. Gordon, M.A., of Balliol College, clearly proves that certain ants neglect

specimens of *Acræas* when they can get other butterflies. Mr. Gordon writes of two *Acræas* captured Jan. 13, 1902, at Old Calabar: "So distasteful do these butterflies seem to be that even the ants will not eat them. These specimens are the only survivors of a set of about twenty. The ants got in and ate all the rest, leaving these, as you see, untouched." It is interesting to note that the species were very different, being *Acræa admatha* and *A. neobule*. The specimens are in the Hope Department, Oxford.

B. *Predaceous Coleoptera*.

A great deal of work remains to be done with the predaceous Coleoptera. So far as I am aware Professor F. Plateau is the only naturalist who has made any important use of them, but there is reason to infer from his experiments that they too are important enemies to aposematic insects. One section of his paper (Mém. de la Soc. Zool. de France, tome vii, p. 375, § 9) is devoted to experiments in which *Abraxas* larvæ were offered to *Carabus auratus*, *Dytiscus marginatus* [*marginalis*], and *D. dimidiatus*. Two of the *Carabi* in confinement were starved for about eleven hours, and then given one full-grown and two smaller larvæ of *Abraxas*. One beetle fed upon the large larva continuously for about an hour, only leaving the thoracic region. The other *Carabus*, of which one antenna was mutilated, after half-an-hour attacked one of the smaller caterpillars and then abandoned it. When the observer returned after a few hours both the smaller larvæ were partially eaten. Twelve hours later the beetles were perfectly well. The experiment was renewed with two fresh *Carabi* starved for eighteen hours. The beetles began to devour the larger of two larvæ given to them, and even fought over it: in an hour only the torn and empty skin remained. By the next morning the second larva had been devoured, and the beetles were quite healthy. Three imagines of *Abraxas* were then offered to two freshly-caught *Carabi*. After three hours one moth was nearly devoured, after about six hours the second, and by the following morning the third. There only remained some fragments of the wings. The beetles were as active as ever. Several larvæ were then thrown into an aquarium containing the two above-mentioned species of *Dytiscus*. The latter at once attacked them, fighting over their prey, which seemed to be entirely consumed.

These results are tolerably decisive; but it would have been more satisfactory if the experiments had been continued for a much longer period and controlled by others in which different forms of food were employed. In this way a convincing test of the wholesome qualities of the larvæ would have been supplied. In other experiments, again, it would have been desirable to offer a wide choice, and ascertain if there are any marked preferences.

Mr. G. A. K. Marshall has also observed one of the *Histeridæ*, *Hister caffer* (Erichs.), eating a far larger beetle than itself, the Scarabæid *Onitis alexis*. He has also observed the same beetle devouring *Aphodii*.

On July 19, 1898, I observed a large Elaterid (*Corymbites virens* ♀) eating the larvæ of *Vanessa urticae* on a nettle beside the mountain road (6000 feet) from Leukerbad to the Gemmi Pass, Valais. The specimens are now in the Hope Department.

C. Predaceous Diptera.

It is convenient to bring together the numerous records of the attacks of *Asilidæ* upon insects into a tabular statement. In its preparation I have received the kindest help and co-operation from Colonel Yerbury, Colonel Bingham, Mr. G. A. K. Marshall, Mr. A. H. Hamm, and Dr. Chapman.

* Specimens in Hope Department, Oxford. † Specimens in Collection of British Museum (Natural History).

COLLECTOR.	LOCALITY.	DATE.	SPECIES OF ASILID.	NAME OF PREV.
J. W. Yerbury.	Trinkomali, Foul Point.	Oct. 26, 1890.	<i>Maira</i> , sp. ? ♀. †	Syrphid, Eumerus, sp. †
J. W. Yerbury.	Mahagany, Trinkomali.	Nov. 30, 1890.	? Sp. and gen. ♀. †	Muscid. †
J. W. Yerbury (Zoologist, 1900, p. 559).	Trinkomali.	Nov. 1890.	<i>Microstylum apicale</i> (Wied.).	Cicadon, <i>Tibicen nubilifera</i> .
J. W. Yerbury.	Nilavelli, Trinkomali.	Nov. 16, 1890.	<i>Microstylum apicale</i> ♀. †	Aceridian. †
J. W. Yerbury (Proc. Linn. Soc., v. 24, Zool., p. 551).	Trinkomali.	1890—91.	<i>Promachus maculatus</i> (Fabr.).	Dragon-fly, <i>Brachythemis contaminata</i> (Fabr.). †
J. W. Yerbury.	Trinkomali.	July 18, 1891.	<i>Scleropogon ambryon</i> (Walk.) ♀. †	Dipteron, <i>Scleropogon ambryon</i> ♀. †
J. W. Yerbury.	Perivipancherun, Trinkomali.	April 21, 1891.	? <i>Philodius</i> , sp. ♀.	Dipteron, Large Tachnid, ? gen. and sp.
J. W. Yerbury.	Trinkomali.	June 25, 1891.	<i>Scleropogon ambryon</i> ♂. †	Butterfly, <i>Triumala himniac.</i> †
J. W. Yerbury.	Periya Kulam, Trinkomali.	Oct. 18, 1891.	<i>Scleropogon ambryon</i> ♀. †	Another Asilid, ? gen. and sp. †
J. W. Yerbury.	Lyndhurst, New Forest.	May 27, 1894.	<i>Diocoria atlandica</i> (L.) ♀. †	Ichneumon. †

* *Specimen in Hope Department, Oriental.* † *Specimen in Collection of British Museum (Natural History).*

OBSERVER.	LOCALITY.	DATE.	SPECIES OF ASILID.	NAME OF INSECT.
J. W. Verburg.	Gravesend.	June 4, 1893.	<i>Dioctria atricapilla</i> (Mg.) †	Ichneumon. †
J. W. Verburg (Trans. Ent. Soc. Lond. 1899, p. 93).	Laboj, Aden.	March 6, 1895.	<i>Pholidus apicatus</i> (v.d. W.) †	Butterfly. Zizera gaika.*
J. W. Verburg (Trans. Ent. Soc. Lond. 1899, p. 93).	Huswah, Aden.	April 14, 1895.	<i>Apoda pectoralis</i> (Wied.) †	Butterfly, Synchloe glaucopne.
J. W. Verburg.	Ledbury.	June 4, 1895.	<i>Dioctria rufipes</i> (Deg.) ♀. †	Ichneumon. †
J. W. Verburg.	Lyndhurst.	June 25, 1894.	<i>Noctamus cyanurus</i> (Loew) ♀. †	Coleopteron, ? gen. and sp. †
J. W. Verburg.	Brockenhurst.	June 14, 1894.	<i>Melichneumon atricapillus</i> (Fallen) ♀. †	Dipteron, Chrysopa (L.)
Guy A. K. Marshall.	Malvern, Natal.	March 28, 1897.	? Gen. and sp.	Butterfly, Precis elgiva.
Guy A. K. Marshall.	Umtali, Mashonaland, 3700 ft.	Dec. 1900.	? Gen. and sp.	Butterfly, Acraea caldarena (Hew.)
Guy A. K. Marshall.	Umtali, Mashonaland, 3700 ft.	Dec. 29, 1900.	<i>Urticus? stans</i> (Loew) ♀.	Butterfly, Lampides boetica.
Guy A. K. Marshall.	Salisbury, Mashonaland, 5000 ft.	May 5, 1901.	<i>Lophonotus? sullas</i> (Fabr.) ♀. 38.0 m.m. across wings.*	Butterfly, Trithemis arteriosa (Burm.) 47.0 m.m. across wings.*

* *Specimen in Hope Department, Oxford.* + *Specimen in Collection of British Museum (Natural History).*

OBSERVER.	LOCALITY.	DATE.	SPECIES OF ASILID.	NAME OF PREY.
Guy A. K. Marshall.	Salisbury. Mashonaland, 5000 ft.	Oct. 6, 1901.	<i>Pronachus</i> , sp., perhaps <i>ragulator</i> (Wied.) ♀.*	Dragon-fly, <i>Trithemis</i> , sp., probably im- mature <i>T. dorsalis</i> (Ramb.).*
Guy A. K. Marshall.	Chirinda Forest, Gazaland, 4500 ft.	Dec. 12, 1901.	<i>Pronachus</i> , sp., probably <i>gracilis</i> (Walk.) ♀.	Acutate, <i>Haliatus</i> , sp., close to <i>torridus</i> (Sm.), but smaller.*
Guy A. K. Marshall.	Salisbury. Mashonaland.	Jan. 26, 1902.	<i>Pronachus</i> <i>agualis</i> (Loew) ♀.	Beetle, <i>Heteromera</i> , <i>Lagria</i> , sp.*
C. T. Bingham.	Doudani Valley, Martaban. U. Tenasserim.	Aug. 27, 1893.	<i>Pronachus</i> , sp.? near <i>flori- baphis</i> (Macq.) ♀. 35 mm. across wings.†	Dragon-fly, <i>Rhyothemis phyllis</i> (Sulz.). 7.8 mm. across wings.†
C. T. Bingham.	Afaran Valley, L. Tenasserim.	April 1898.	<i>Isotoma</i> ? sp. ♀.*	Acutate, <i>Melipona apicalis</i> (Sm.).*
W. R. Ogilvie-Grant (Zoologist, 1900, p. 559).	Socotra.		<i>Pronachus sokotrar</i> (Ric.) M.S. ♂.†	Small Cicada ? sp.†
E. B. Poulton.	Near Brieg, Valais, Switzer- land, 2450 ft.	July 24, 1898.	<i>Dasyopogon diadema</i> (Fabr.) ?.	Dipteron. <i>Sarcophaga</i> , sp.*
E. B. Poulton.	Montserrat, near Barcelona.	July 15, 1901.	<i>Eristalis</i> ? <i>apicalis</i> (Loew) ♂ & in cop.; the lower insect, pro- bably ♀, with prey.*	Dipteron; Anthomyid, <i>Mydaea</i> , sp., probably either urbana or pagana.*

* Specimen in Hope Department, Oxford. † Specimen in Collection of British Museum (Natural History).

OBSERVER.	LOCALITY.	DATE.	SPECIES OF ANILID.	NAME OF PREV.
E. B. Poulton.	Cerbère, Eastern Pyrenees.	July 17, 1901.	<i>Epitriptus arthriticus</i> (Zeller) ♀.*	Acridian, <i>Podisma frigida</i> (Boh.) ♂.*
E. B. Poulton.	Cerbère, Eastern Pyrenees.	July 17, 1901.	<i>Epitriptus arthriticus</i> (Zeller) ♀.*	Acridian, <i>Podisma frigida</i> (Boh.) ♂.*
G. C. Nurse.	Disa, Bombay Presidency.	June 1897.	<i>Nodulatus</i> , sp., perhaps <i>longistylus</i> (Wied.) ♀.	"Beetle twice its weight."
G. C. Nurse.	Disa, Bombay Presidency.	Oct. 1899.	<i>Nodulatus</i> , sp., perhaps <i>griseus</i> (Wied.) ♀.*	Butterfly, <i>Catochrysops contracta</i> .
A. H. Hamm.	Port Bon, Eastern Pyrenees.	June 24, 1901.	<i>Dasypteron diadema</i> (Fabr.) ♀.*	Aculeate, <i>Poliastes gallica</i> .*
J. C. Bowring.	Hong Kong.	Presented to B. M. 1861.	<i>Microstylus dux</i> (Wied.) ♀.†	Beetle, Protetia mandarinae, "its beak through the elytra of the Cetonia."
T. B. Fry.	Probably Poona.	About 1888.	<i>Lacnecera</i> sp. ♀.*	Aculeate, <i>Apis florea</i> ♀ (Fabr.).*
T. A. Chapman (Ent. Record, 1902, p. 72).	Tragacete, Albaracin Mts., Spain.	July 18—26, 1901.	<i>Laphria gibbosa</i> (Linn.) ♂ and ♀ in cop.; the lower insect, the ♀, with prey.*	Beetle, Buprestis (Ancylocheira) flavomaculata, proboscis through cephalothoracic articulation.* A different beetle also seen transfixed by the same species.

Colonel Bingham has sent me the following notes of his observations on *Asilidæ*: "With regard to flies of the family *Asilidæ* and spiders attacking butterflies, I find only a very few scattered notices of cases which I had seen, but no details, I am sorry to say. So far as I can remember I have seen these flies once or twice actually capture butterflies, and in one instance I find it noted in my diary that I found an *Asilus* with a *Junonia hierta* which was still slightly quivering its wings. I have seen the flies not once, but often swoop at butterflies, dragon-flies, and bees. I cannot, however, find any particular note of that case of the *Asilus* with a dragon-fly the specimens of which are in the British Museum. What note I made was written on the paper envelope in which the specimens had been put away. With regard to the *Asilus* which I found attacking the dammar bees (*Melipona*), I find that I have noted that they, the flies, persistently hover round the nest-mouth of the dammar bees, and catch the latter on the wing as they issue from the nest. The flies, so far as I have noticed, never eat their prey on the wing, but retire to a bush holding their prey with their long hairy legs."

A study of the table at once shows that the *Asilidæ* are most indiscriminate in their attacks. The stings of the Aculeates, the distasteful qualities of *Danaïdæ* and *Acræidæ* and of the odoriferous *Lagriæ*, the hard chitinous covering of Coleoptera, the aggressive powers of Odonata, are alike insufficient protection against these active and voracious flies. The only tendency towards specialization in the direction of any particular group of prey appears to be manifested in the preference of the slender Asilids of the genus *Dioctria* for Ichneumonids.* The far greater frequency with which the female Asilid has been observed with prey is sufficiently accounted for by the larger size of this sex and the more important part borne by it in reproduction.

Looking at the table as a whole, and the large proportion of attacks made upon specially-defended insects, the

* Since this sentence was written I have captured (July 1902) many specimens of *Dasypogon diadema* with prey at La Granja, Sierra Guadarrama, Spain. The great majority of these were sucking Aculeates, especially the hive-bee. Another species of Asilid, on Penalara, also exhibited an apparent preference for Coleoptera.—E. B. P.

conclusion is suggested that Bates was mistaken in supposing that Asilid flies play no part as the enemies of *Heliconiinae* and *Ithomiinae*.

7. LEPIDOPTERA WITH WARNING COLOURS SPECIALLY
LIABLE TO THE ATTACKS OF PARASITIC INSECTS.
(G. A. K. M.)

[The late Erich Haase in his work on mimicry (English translation "Researches on Mimicry," etc., Pt. II, Stuttgart, 1896) continually made the assumption that the immunity of *Danainae*, *Acræinae*, and other specially-protected groups is absolute, and extends to the attacks of parasitic Hymenoptera and Diptera as well as to those of insect-eating vertebrates. A little reflection upon the rate of multiplication of animals, and especially of insects, makes it clear that any such absolute immunity is an impossibility. A high degree of protection from the attacks of the generality of insect-eating animals will always be found to be compensated by the attacks of special enemies, and probably very largely by that of insect parasites. I brought forward this argument in 1890 ("Colours of Animals," London, p. 181); and Haase, without attempting to meet it, made the crude assumptions which will now be dismissed, once and for all, by the numerous observations recorded below.—E. B. P.]

Estcourt, Oct. 15, 1896.—We brought seventy-five larvæ of *Acræa anacreon* home with us from Ulundi to Estcourt, and no less than twenty of them were killed by a Dipterous parasite, so that, although it may be protected in the imago stage, the percentage of larval deaths must be very high.

Malvern, Feb. 21, 1897.—I certainly cannot understand Haase's attitude with regard to protection from parasites. There are such patent examples to disprove it among European "whites." Out of eight pupæ of *Acræa horta* that I bred this season no less than five were killed by a Dipterous parasite.

[I have also received from Mr. Marshall two cocoons and two imagines of an ichneumon bred from *Acræa cabira* at Malvern. They bear the date April 1897.—E. B. P.]

Umkomaas Mouth, Natal; Sept. 3, 1897.—I think it is highly probable that *Byblia ilithyia* will prove to be distasteful as you suggest; but so far as my experience goes

the larvæ are very free from parasites, which in my opinion tells somewhat against that view.

Salisbury, March 6-10, 1898.—Of four larvæ of *L. chrysippus* I have taken this season two were killed by a parasitic fly [probably a *Tachina*] which attacks many different butterfly larvæ.

In his "Rhopalocera Malayana" (p. 407) Mr. Distant writes: "Mr. W. F. Kirby has kindly drawn my attention to the fact that several species of *Chalcis* have been reared from East Indian Danaiids." *

[Colonel J. W. Yerbury at Aden "lost a great number of *chrysippus* larvæ from the attacks of a large dipterous parasite, one of the *Tachininae*" (Journ. Bomb. Nat. Hist. Soc., 1892, p. 209).

Professor Félix Plateau, in his interesting paper on *Abraxas grossulariata*, L. (Mém. de la Soc. Zool. de France, tome vii, 1894, p. 375), also referred to on pp. 325-7, states that he found twenty-two caterpillars out of fifty-one, 43 per cent., attacked by insect parasites, viz. of Hymenoptera, two species of *Microgaster* and one of *Ichneumon*; of Diptera, the Tachinid *Erorista vulgaris* (Fallen). The caterpillar, *pace* Professor Plateau, is *most conspicuous*, and, as the Professor admits in the above-quoted paper, is refused by European insect-eating vertebrates with wonderful unanimity.

In the autumn of 1888 I found the conspicuous gregarious larvæ of *Pieris brassicæ* suffered to an enormous extent from the attacks of *Ichneumonidæ*. No less than 424 mature larvæ out of 631 died from this cause (Trans. Ent. Soc. Lond., 1892, p. 439). I have also observed an excessively high rate of mortality from the same cause among the conspicuous specially-defended larvæ of *Porthesia auriflua*. Dr. F. A. Dixey informs me that he has found the larvæ of *Euchelia jacobææ* much infested by ichneumons.—E. B. P.]

8. EXPERIMENTS ON LIZARDS AND FROGS. (G. A. K. M.)

[Experiments with lizards and frogs were few and the results negative. A large number of the S. African species are no doubt specialized to eat only certain kinds of food, and these would be useless for experiment if their natural

* The names of *Chalcis cuplea*, Hope, and *C. albicrus*, Klug, are specially mentioned.

prey did not include members of the insect Order which it was desired to test. European lizards freely eat insects of all Orders, and have been found very satisfactory for such experiments. The African species which Mr. Marshall has actually seen hunting butterflies (see p. 435) should afford very valuable testimony as to the relative palatability of various Lepidopterous species and groups. Even if intolerant of captivity, they would probably thrive in an enclosure out of doors, with plenty of air, sun, and space. —E. B. P.]

Estcourt, Oct. 15, 1896.—I have just got a lizard to try experiments on with regard to the edibility of insects, but though it eats Diptera and some Orthoptera readily, it will not look at any of the butterflies I have given it, viz. *Terias brigitta*, *Pontia hellica*, and *Zeritis taikosama*. I had previously tried an Agama lizard with the same result, as I found that its natural food consisted almost entirely of ants.

Malvern, Feb. 21, 1897.—I have found *Pontia hellica* to be distasteful to a lizard.

Salisbury, March 6–10, 1898.—I kept a lizard for about a week, but it refused to eat any of the butterflies I gave it, but as it also refused termites the results were unreliable, and I let it go. In experiments of this kind the natural habits of the predatory animal must be taken into account, and the fact that a lizard prefers a fly to a butterfly may in some cases have no greater significance, so far as mimetic problems are concerned, than that a frugivorous bird prefers a berry to a butterfly.

Salisbury, June 5, 1898.—I have made several attempts at experiments with butterflies and lizards, but with no satisfactory results, as the latter seem to be unwilling to eat anything at all in captivity, remaining in a sort of listless condition.

Malvern, May 14, 1897.—Caught three frogs and put them in a box, and put in a wingless specimen of *Acræa natalica*. After a short interval the largest frog swallowed it. He made no sign to show that it was distasteful, nor did he disgorge it afterwards. For several days I put in specimens of various species, both edible and otherwise, but as none of the frogs paid the slightest attention to them I ceased to experiment.

9. EXPERIMENTS ON CAPTIVE KESTRELS (*Cerchneis rupicoloides* and *C. naumanni*). (G. A. K. M.)

1899.

Salisbury, Mashonaland.

- January 2. Offered a young kestrel (*Cerchneis rupicoloides*) an *Acrida caldarena*; he took it in his beak, held it for a few seconds and then threw it away with a sharp shake of the head. Then gave him a *Byblia ilithyia*, which he accepted, but after making one or two pecks at it let it drop and would not touch it when it was again offered. I then tried him with an example of *A. nohara-halali* and *A. doubledayi-axina*, but he would have nothing to do with them.
- „ 7. Gave the kestrel a large Buprestid beetle (*Psiloptera valens*, Pér. *il.*); he seized it in his beak with a cry of evident pleasure, then holding it in his foot tried to eat it, but after a peck or two it slipped from his grasp; I gave it back to him several times, but always with the same result—the beetle was too slippery. *Psiloptera* are all eaten readily by baboons, and it would appear from this that their hard, shiny integuments combined with their torpedo-like shape form a very efficient protection (apart from their procryptic colouring) from all birds which are not sufficiently large to swallow them entire.
- „ 8. Offered kestrel two *Blepisanis haroldi*, a small Longicorn with Lycoid markings, but he would not touch them; then a *Lycus rostratus*, at which he pecked but was evidently displeased with the taste, and neglected it.
- „ 12. Gave kestrel a *Precis pelagis*, *Junonia cebreus*, *Precis sesamius* ⊕ and *Atella phalantha*. He ate them all with evident relish, though he seemed to experience a little difficulty in managing them at first, as he could not get a good hold with his claw in order to pull them to pieces. So

the first two were practically swallowed whole, but the others were eaten piecemeal. I then offered a larva of *Limnas chrysippus*, which he accepted and held for some moments in his claw as though in doubt, but finally let it drop after a half-hearted peck. On re-presentation he would not touch it, so in order to restore confidence I gave him a grasshopper, on which insects he is usually fed. The species offered happened to have some rather light-green, yellow, and black markings; he took it with evident distrust and soon dropped it, although it was a species he had often eaten before. Thinking that the refusal was due to his experience with the brightly-marked larva of *L. chrysippus*, I offered some dully-coloured green and brown grasshoppers, which were readily eaten, and after them he also ate the one previously refused. I then offered a larva of *Acræa rahira*; he evinced a decided interest in it, but, although it crawled about over his feet, absolutely refused to touch it. This however may have been due to a generalized impression that all caterpillars were distasteful.

- January 13. *Cerchneis rupicoloides* ate one *Catopsilia florella*. A young bird of another species (*C. naumanni*) accepted a dead *Papilio demodocus*; for a few moments he seemed undecided where to attack it: then noticing the eye-spots in the hind-wing he promptly pecked them out, afterwards eating the rest.
- „ 16. *C. naumanni* ate three *Terias brigitta*; both this species and *C. rupicoloides* refused the Lycoid *Prionocerus dimidiatus* with unmistakable signs of dislike.
- „ 21. *C. naumanni* ate one *Precis pelasgis*, one *Axiocerces harpax*, one *Terias brigitta*, one *Catopsilia florella*, and one *Precis sesamus* (*natalensis* form) \oplus , all with

evident appreciation. *C. rupicoloides* appeared to have become tired of butterflies, refusing all, even those it ate before. Swynnerton found that it continually refused the brightly-coloured grasshopper mentioned above, but always ate it with relish when it had been dipped in meal to obscure its colours. *C. naumanni* on the other hand never refused the insect.

- January 22. *C. naumanni* accepted a *Papilio corinnus*, but seemed in some doubt as to its edibility; he finally ate the thorax and threw away the abdomen. *Acræa halali* was then offered, tasted, and rejected. *Acræa anemosa* and *Limnas chrysippus* were likewise refused, and shortly afterwards one *Byblia ilithyia* and one *Terias brigitta* were eaten.
23. *C. rupicoloides* escaped, and all the following notes refer only to *C. naumanni*. Kestrel ate one *Dichtha inflata* and one *Amblysterna vittipennis*. A *Lagria*, sp., was tasted and rejected.
25. When very hungry the bird ate part of an *Acræa caldarena*, throwing away the rest. Subsequently he ate four *Belenois severina*, one *Junonia cebrene*, and one *Precis sesamus* (*natalensis* form).
28. Two *Byblia ilithyia* eaten by kestrel. A *Clythra wahlbergi*, with strong Coccinellid odour, was eaten by the kestrel after some hesitation. Kestrel refused the Coccinellid *Epilachna dregei*.
29. A Longicorn (*Ceroplesis fallax*, Pér.) offered to kestrel, which had been kept without food for some time. He was evidently nervous and much impressed by the stridulation of the insect. I therefore pulled the head off the beetle, and the hawk then ate it, but very slowly and in such a way as to lead me to suppose that it was not altogether palatable. Gave a *Piezia selousi*, head first, to kestrel, which ate it readily though evidently noticing

the acidity of the abdomen. A *Polyhirma enigma* was at once eaten by kestrel. I then offered him *Graphipterus lineolatus*, tail first; he pecked at it and received a small discharge of acid in the mouth, whereupon he shook his head and began wiping his beak vigorously on the perch, as though to get rid of the taste. Upon the beetle being presented head first, he took it with caution and ate it. The same results were obtained with *Graphipterus wahlbergi*, *G. bilineatus*, and *G. lineolatus*, they being refused when presented tail first and eaten when reversed. It should be noted that these beetles all discharge their secretions violently when captured, and therefore the kestrel would probably receive a comparatively small dose of the acid.

February 1. Gave kestrel an *Atella phalantha*; he seemed a good deal doubtful about it at first, but finally ate it without any signs of distaste. He then ate a *Junonia cebreus* and a *Byblia ilithyia* with manifest enjoyment. I then offered *L. chrysippus*; he accepted it readily, pulled off the head which he discarded, pecked a little at the tough thorax and wings, and then let it drop; on offering it again he took it, gave it a few pecks and jerked it away with his beak. He then ate a *Hamanumida daedalus* and accepted an *A. caldarena*, of which he ate a small part of the abdomen and threw away the rest. After this he ate with pleasure a *P. sesamus* (*natalensis* form), *J. cebreus*, and *B. ilithyia*. Several *Onitis alexis* were then given to the kestrel, which ate them readily. *Anomalipus plebeius* was too hard for him, and after five minutes' hard pecking he had only succeeded in pulling off the head; I therefore broke it up for him, and it was promptly eaten. He then refused *Clinteria infusata*, *Mylabris holo-*

sericea, *Clerus* sp. (entirely scarlet, with strong verbena-like smell), and *Prionocerus dimidiatus*.

- February 3. Kestrel ate several dull-coloured *Curculionidæ* (*Oosomus*, sp., and *Eremnus*, spp.), refusing several *Onthophagus gazella* which were offered, also *Lycus ampliatus*, *L. rostratus*, and *L. constrictus*, all of which were tasted and were very evidently unpleasant.
- „ 6. Kestrel refused *Zonitis*, sp., *Eletica rufa*, *Mylabris palliata*, and *Diacantha conifera*, after tasting each.
- „ 15. The kestrel had been starved for twenty-four hours, and was very hungry. He ate the following insects, in the order given, with great avidity: two *Teracolus achine*, one *B. ilithyia*, two *Atella phalantha*, one *Junonia cebrene*, and one *Papilio corinnæus*. I then gave him an *Acræa caldarena*, of which he first ate the head and swallowed the rest whole, one *A. rahira* was also swallowed whole; *L. chrysippus* was then offered; the bird ate the head, which seemed to raise suspicions in his mind, for he sat considering for some moments, and then began pecking at the thorax and wings and finally dropped it; on re-presentation he seized the butterfly, gave a few pecks at it, and jerked it away. Then one *Acræa axina* and two *A. halali* were swallowed whole, but *A. caldarena* which followed was only partially eaten, fully half being discarded. Another *L. chrysippus* was offered, and the entire head and thorax was eaten before it was thrown down. Later, the bird swallowed whole another *A. rahira* subsequent to eating several grasshoppers.
- „ 28. Gave kestrel a *B. ilithyia*, which was eaten rapidly, and a second as well. He then ate a *Precis pelasgis* and another *ilithyia*, but an *Acræa halali* was pecked at once or twice and thrown away, and a fourth

ilithyia was treated in the same way, being apparently mistaken for an *Acrwa*. I then offered a female *Anoplocnemis curvipes*; the bird ate the head, but evidently in some doubt; it continued with the thorax however, but showed its dislike by repeated sharp shaking of the head, and finally dropped the abdomen. I put a male of the same bug on its perch, but though it examined it carefully it would not touch it; yet this species is eaten greedily by the baboons.

[There are several very significant results from the above-recorded experiments on kestrels. The rejection of *Byblia*, after trial and rejection of an *Acrwa*, may have been due to the superficial resemblance. On the other hand, this bird (*C. rupicoloides*) was apparently not fond of butterflies, for after eating (Jan. 12) *Precis*, *Junonia*, and *Atella* and (Jan. 13) *Catopsilia*, he refused all Rhopalocera. The refusal of an Acridian marked with bright green, yellow, and black, and its acceptance when the colours were hidden was almost certainly the result of unpleasant experiences with conspicuously-marked insects, of which a particular instance was afforded when the larva of *L. chrysippus* was offered. Such association of impressions brought about by very imperfect resemblances are of great importance in helping us to understand the origin of mimicry, both Batesian and Müllerian, in slight accidental resemblances of a very rough and imperfect kind. It also warns us not to regard as far-fetched or absurd those imperfect likenesses which may well be the early stages of incipient mimicry. The refusal of the Lycoid Longicorn *Blepisanis* may be similarly due to a previous experience of *Lycidæ*, or it may be truly distasteful and synaposematic. The latter interpretation is certainly true of the Lycoid Melyrid *Prionocerus* also refused by the kestrel "with unmistakable signs of dislike."

The other species of kestrel, *C. naumanni*, was much fonder of butterflies and of insects generally, eating the brightly-coloured grasshopper on all occasions. The fact that it took special notice of and pecked at the eye-spots on the hind-wing of *P. demodocus* is of much interest, and recalls an observation of my own quoted on pp. 440, 441. Such observations strongly confirm the interpretation of

eye-spots, especially upon the under-side of the wings, as directive marks leading an enemy to attack a non-vital part, and they tend to refute Portschinski's explanation of them as the representation in colour of drops of some specially-protective fluid (see p. 398).

Butterflies of different groups, *Hesperidæ*, *Pierinæ*, *Nymphaliniæ*, were freely eaten, but the rejection of the abdomen of *Papilio corinnæus* by the captive bird which afterwards ate *Byblia* and *Terias*, can only be explained on the supposition of unpalatability, and the same was evidently true in a more marked degree of *Acræas* and *L. chrysippus*, although parts of these would sometimes be eaten, while on Feb. 15, after starvation for twenty-four hours, many *Acræas* were swallowed whole. The behaviour on this occasion renders it certain that, as in the case of *Bucorax caffer*, *L. chrysippus* was far more distasteful to the kestrel than the *Acræas*.

The rejection, after trial, of the evil-smelling Coreid bug *A. curvipes*, greedily eaten by baboons, is a good example of the difference in value of the same defence with different enemies.

The treatment of Coleoptera almost invariably supported the theories which explain the meaning of insect colouring as cryptic, warning, etc.

The following beetles were eaten by the kestrel: *Curculionidæ*, with cryptic colouring (*Oosomus*, sp., and *Eremnus*, spp.); the large, slow-moving, conspicuous, black, earthy Heteromeron *Anomalipus plebeius*, when the chitin was broken; the smallish Buprestid *Amblysterna vittipennis* (dark metallic green or coppery with white stripe on each elytron); the Heteromeron *Dichtha inflata*, dark brown with reddish stripes, conspicuous and slow-moving like *Anomalipus*; the medium-sized Scarabeid *Onitis alexis* with elytra and legs brown, and thorax iridescent green.

It is probable that most of the defensive fluid had been already discharged in the case of the *Carabidæ* of the genera *Piezia*, *Polyhirma*, and *Graphipterus*, of which the acid secretion was seen to be a very positive protection when there was opportunity for its operation on a normal scale. The Longicorn *Cercoplessis fallax* with a Cantharid type of colouring may be synaposematic, as it was only eaten very slowly although the bird had been kept without food. The impression produced by the stridulation is of much interest (see p. 403).

The following beetles were refused, usually after tasting :—

CANTHARIDÆ :—*Mylabris palliata*, *M. holosericea*, *Eletica rufa*, *Zonitis* sp. (all most conspicuous).

COCCINELLIDÆ :—*Epilachna dregei* (characteristic colouring).

CLERIDÆ :—" *Clerus* " sp. (scarlet).

PHYTOPHAGA :—*Diacantha conifera* (Lycoid).

MELYRIDÆ :—*Prionocerus dimidiatus* (Lycoid).

LYCIDÆ :—Three characteristically coloured species of *Lycus*.

CETONIIDÆ :—*Clinteria infuscata* (orange thorax with two black spots, brown elytra, sometimes black).

HETEROMERA :—*Lagria*, sp. Probably distasteful, conspicuous and synaposematic with Phytophaga.

SCARABÆIDÆ :—*Onthophagus gazella*, smallish Scarabæid with brown elytra and iridescent dark green thorax and head.

With the possible exception of the last named, all these species possess distinct aposematic colouring, and nearly all belong to groups which are much mimicked, or fall into important synaposematic combinations.

Mr. Marshall specially points out that the Kestrel, *C. naumanni*, was young, and it is probable that it had never before had experience of many of these species.—E. B. P.]

10. EXPERIMENTS ON A TAME GROUND HORN-BILL (*Bucorax caffer*). (G. A. K. M.)

Malvern, Natal, May 14, 1897.

March 14. Gave a tame ground horn-bill (*Bucorax caffer*), belonging to Col. J. H. Bowker, the following butterflies: two male *A. serena*, one *P. lyæus*, one male *H. misippus*, one male *A. serena*, all of which he ate readily, taking them in the end of his beak, crushing the thorax and throwing them down his throat. I then gave him *L. chrysippus*. He took it, crushed the thorax and dropped it at once. A second specimen given a short time afterwards was treated in the same manner.

„ 24. Gave the following butterflies to ground horn-bill: three *A. encedon*, one *A. petraea*,

one *P. aganice*, two *J. clelia*, three male *H. missippus*, one *P. tropicalis*, two *P. brasidas*, two *P. demodocus*, one *P. lyæus*, and two *R. forestan*. He ate every one without the least hesitation, and evidently appreciated them, as he would follow me about, waiting for more.

- April 1. Gave ground horn-bill one *A. petraea*, two *A. cabira*, one *P. brasidas*, one male *H. missippus*, and one *P. esebria*, all of which he ate readily.

[It has already been pointed out that the acceptance of insects by insectivorous animals in captivity is no proof of their normal likes or dislikes in a wild state. Such acceptance only proves what their action would be when they had been, from some exceptional cause, kept without their normal food in its usual quantity and variety. Hence the fact that the *Acræas* were devoured is no evidence that they are normally eaten except in a time of unusual hunger. On the other hand, the rejection of two *L. chrysippus*, after three *Acræas* had been readily eaten, indicates that the former butterfly is decidedly distasteful to this species of bird. It must be remembered that five *Acræas* were freely eaten on the next occasion. A comparison with the experiments on Mantides is interesting.—E. B. P.]

11. THE INSECT-FOOD OF WILD SOUTH AFRICAN BIRDS. (G. A. K. M.)

[Even more important than the results of experiments are the observations made and collected by Mr. Marshall upon the contents of the stomachs of birds, and the record of actual attacks made by birds upon insects, which have been witnessed in the field. The contents of birds are clearly shown in the two following tables, A and B, which are printed just as I received them from Mr. Marshall, except that I have added a brief description of the general appearance of those insects which seemed to require it. Mr. Marshall had only supplied such a description in three or four cases. In future records of this kind it will be advisable for the observer on the spot to supply such notes, together with a brief account of the habits, inasmuch as conspicuousness or concealment depend upon these quite as much as upon colour and pattern.—E. B. P.]

TABLE A.—Contents of birds, probably 1898, unless otherwise stated, and Salisbury when no other locality is mentioned.

BIRDS.	INSECTS, ETC.	GENERAL APPEARANCE OF INSECTS.
<i>Macronyx capensis</i> .	COLEOPTERA, <i>Cleonus</i> sp., <i>Eremnus</i> sp., <i>Syagrus</i> <i>puncticollis</i> , Lefev., <i>Sympieziorrhynchus</i> sp.	<i>Syagrus</i> , a shining black, medium-sized Phytophagous beetle (<i>Eumolpidæ</i>). All others are weevils, and probably all with cryptic colouring.
<i>Irrisor erythrorhynchus</i> .	HOMOPTERA, <i>Pyrops</i> sp. COLEOPTERA, <i>Platypria</i> <i>mashuna</i> , Pér., <i>Anthaxia</i> sp.	<i>Pyrops</i> , at rest are red-brown or greyish insects. <i>Platypria</i> , tawny with brown spots, very spinous (<i>Hispidæ</i>). <i>Anthaxia</i> , small green or coppery Buprestid.
<i>Coracias garrula</i> .	COLEOPTERA, <i>Gymnopleurus</i> <i>fastiditus</i> , Har.	Large, sooty-black, smooth Scarabeid.
<i>C. caudata</i> .	CRABS. COLEOPTERA, <i>Agrilus</i> sp., <i>Anthia pachyoma</i> (!).	<i>Agrilus</i> , small Buprestids, colour varies. <i>Anthia</i> , huge black Carabid with very powerful mandibles.
<i>C. spatulata</i> .	DIPTERA, fly-maggots from carrion.	
<i>C. olivaceiceps</i> .	ORTHOPTERA, <i>Phymatrus</i> <i>morbillosus</i> , L. (a large evil-smelling bright-green locust with purple and crimson hind-wings).	Very conspicuous, with red thorax and head; legs red and yellow.
<i>Melittophagus pusillus</i> .	COLEOPTERA, <i>Onthophagus</i> , sp.	Genus of <i>Scarabæidæ</i> , varying much in size: metallic or black.
<i>Merops natalensis</i> .	COLEOPTERA, <i>Mytabris</i> <i>oculata</i> , Thunb. (!).	Characteristic Cantharid, aposematic, orange and black colours.
<i>Cuculus gularis</i> .	COLEOPTERA, <i>Nyassinus</i> <i>lugubris</i> , <i>Sphenoptera</i> <i>disjuncta</i> , <i>Hoplonyx</i> sp.	<i>Nyassinus</i> , small red-brown, rough Cetoniid, probably cryptic. <i>Sphenoptera</i> , dark metallic, coppery, moderate-sized Buprestid. <i>Hoplonyx</i> , medium-sized, black often polished, Heteromera (<i>Tenebrionidæ</i>).
<i>Asturina monogrammica</i> .	ORTHOPTERA, <i>Clonia wahlbergi</i> . CENTIPEDES.	<i>Clonia</i> is a fine Locustid living among the leaves of trees. It is certainly procryptic.
<i>Fulco subbutco</i> .	COLEOPTERA, <i>Pentodon</i> <i>nireus</i> , Burm., <i>Onitis</i> <i>alexis</i> , <i>Anomala</i> sp.	<i>Pentodon</i> , large black Dynastid. <i>Onitis</i> , medium-sized Scarabeid, elytra and legs, brown; thorax iridescent green. <i>Anomala</i> , pale yellow brown, or metallic <i>Rutelidæ</i> : moderate-sized beetles.

TABLE A.—(continued.)

BIRDS.	INSECTS, ETC.	GENERAL APPEARANCE OF INSECTS.
<i>Cerchneis rupicoloides.</i>	CENTIPEDES.	
<i>C. naumanni.</i>	COLEOPTERA, <i>Heteronychus lica</i> s, Klug., CENTIPEDES. ARACHNIDS, <i>Solpuga marshalli</i> , Poc.	<i>Heteronychus</i> , smallish black, rather shining Dynastid. <i>Solpuga</i> is red-brown, distal part of 4th leg black, broad median black band on abdomen which is clothed at sides with yellowish-white hairs. It runs very swiftly and its habits are strongly procryptic.
<i>C. amurensis.</i>	COLEOPTERA, <i>Hydaticus</i> , sp.	Moderate-sized, oval, polished dark-brown <i>Dytiscidæ</i> .
<i>Bubo maculosus.</i>	COLEOPTERA, <i>Hesperophanus amicus</i> , white.	A large red-brown Cerambycid: procryptic.
<i>Herodias lucidus.</i>	Dragon-flies and aquatic Hemiptera.	
<i>Ciconia abdumii.</i>	COLEOPTERA, <i>Psammodes ventricosus</i> , Fahr., <i>P. scabratus</i> , Gerst., <i>Polyhirma semisuturata</i> , Chd., <i>Piezia marshalli</i> , Pér., <i>Scarites</i> , sp. HYMENOPTERA, Ants of the genus <i>Carabura</i> .	<i>Psammodes</i> , both species are large dull-brown Tenebrionid Heteromera. <i>Polyhirma</i> , moderate-sized, black Carabid with white markings. <i>Piezia</i> , a Carabid superficially similar to last. <i>Scarites</i> , shining black Carabids of variable size; large mandibles.
<i>Namida coronata.</i> Shot by C. F. M. Swynnerton at Mazoe, Mashonaland, 4000 ft.	COLEOPTERA, 2 <i>Psiloptera chalcophoroides</i> , Pér., 1 <i>Hipporhinus bohemani</i> , Fahr., 1 <i>Phantasis gigantea</i> , Guér., 1 <i>Macrocoma aurcovillosa</i> , Mash. These five specimens were taken from the crop, December 25, 1898, by Guy A. K. Marshall. They are now in the Hope Collection, Oxford, and are extraordinarily perfect, retaining the legs and in some cases the antennæ.	<i>Psiloptera</i> , largish iridescent bright-green Buprestids. <i>Macrocoma</i> , a small golden-green iridescent Phytophagous beetle. <i>Hipporhinus</i> , a large brown rough cryptic weevil. <i>Phantasis</i> , a large Longicorn generally similar to the above, and probably mimetic of certain very hard <i>Curculionidæ</i> .
<i>Merops natalensis</i> , September 1901.	LEPIDOPTERA HETEROCERA, the Saturniidæ <i>Pseudaphelia apollinaris</i> and <i>Cirina similis</i> .	The moths both conspicuous, slow, day-flying, and probably distasteful species. <i>Pseudaphelia</i> , is large semi-transparent, whitish with black markings; <i>Cirina</i> is still larger and dull pink.

TABLE B.—*Insects, etc., in stomachs of birds (probably 1898), Salisbury.*

COLEOPTERA.	BIRDS.
<i>Polyleis decorus</i> (largish weevil, varying much in colour, but always with more or less of a pattern).	<i>Oriolus notatus</i> , <i>Coracias caudata</i> , <i>Halcyon pallidiventris</i> .
<i>Trochilus</i> sp. (small rounded often polished black-brown or greenish Lamellicorns; probably mimics of <i>Galerucidae</i> , <i>Chrysomelidae</i> , and <i>Coccinellidae</i>).	<i>Bradyornis marquensis</i> , <i>Fringillaria taho-pisi</i> .
<i>Cassida</i> (<i>Aspidomorpha</i>) <i>punctata</i> , F. (medium size, abundantly black-spotted, colour probably reddish-brown when fresh).	<i>B. marquensis</i> , <i>Irrisor erythrorrhynchus</i> , <i>Campothera bennetti</i> .
<i>Atides hæmopterus</i> , Boh. (smallish weevil with red-brown white-spotted elytra and black thorax and head).	<i>Prionops talacoma</i> .
<i>Oosomus</i> sp. (an entirely black, arboreal or subcortical weevil).	<i>Graculus pectoralis</i> , <i>Upupa africana</i> , <i>Irrisor erythrorrhynchus</i> , <i>Campothera bennetti</i> .
<i>Zophosis</i> sp. (black quick-running Heteromeran).	<i>Geocichla litsitsirupa</i> .
<i>Onthophagus gazella</i> (smallish Scarabeid with brown elytra and iridescent dark-green thorax and head).	<i>Caprimulgus rufigena</i> , <i>Falco subbuteo</i> (in large numbers).
OTHER INSECTS, ETC.	
Pentatomid bugs.	<i>Geocichla litsitsirupa</i> , <i>Laniarius guttatus</i> , <i>Irrisor erythrorrhynchus</i> , <i>Cerchneis amurensis</i> , <i>Coccys glandarius</i> .
Reduviid bugs.	<i>Macronyx capensis</i> , <i>Rhinopomastus cyanomelas</i> .
Ant-lion larvæ.	<i>Thamnotæa cinnamomeiventris</i> .
Ants.	<i>Bradyornis marquensis</i> , <i>Pratincola torquata</i> , <i>Monticola angolensis</i> , <i>Saxicola pileata</i> , <i>Buchanga assimilis</i> , <i>Thamnotæa cinnamomeiventris</i> , <i>Grateropus kirkii</i> , <i>Lophoceros leucomelas</i> , <i>Campothera bennetti</i> , <i>Oreopsis egregia</i> .

TABLE B.—(continued.)

OTHER INSECTS, ETC.	BIRDS.
Other Hymenoptera.	<i>Rhinopomastus cyanomelas</i> , and all four species of bee-eaters.
Hairy caterpillars.	<i>Oriolus larvatus</i> , and all the cuckoos.
Millepedes.	<i>Turdus libonyanus</i> .
Scorpions.	<i>Coracias olivaceiceps</i> , <i>Cerchneis rupicoloides</i> , <i>Asturimula monogrammica</i> (apparently favourite food with this species).
VERTEBRATES.	
Lizards.	<i>Melierax polizonus</i> , <i>Astur polizonoides</i> , <i>Aquila wahlbergi</i> , <i>Circæus pectoralis</i> , <i>Cerchneis rupicoloides</i> , and <i>Glaucidium perlatum</i> .
Snakes.	<i>Astur polizonoides</i> , <i>Butco jakal</i> , <i>Circæus pectoralis</i> , <i>Bubo maculosus</i> .

RESULTS OF TABLES A AND B.

[The almost complete absence of the members of aposematic Coleopterous groups is very marked. In fact, the whole of the numerous beetles are probably cryptic, with the following exceptions. The species of the Eumolpid genus *Syagrus* is probably distasteful; for it freely exposes itself on leaves, where its shining black appearance renders it conspicuous. It is worthy of note that the only bird in which it was found, *Macronyx capensis*, also ate Reduviid bugs. The Phytophagous *Macrocoma aureovillosa* belongs to a probably distasteful group, but it is itself green in colour; it was only eaten by one species. The Hispid *Platypria* is probably distasteful, and here too the only species of bird which ate it, *Irrisor erythrorhynchus*, also ate the conspicuous *Cassida* (*Aspidomorpha*) *punctata* and Pentatomid bugs. The above-named Cassid was also found in two other species of bird. The most remarkable exception is however the typically-coloured Cantharid, *Mylabris oculata*, only detected in *Merops natalensis*. Here we find the interesting proof that under certain circumstances, and with certain enemies, the most marked distasteful

or unwholesome qualities accompanied by the most conspicuous orange and black aposematic coloration may afford no protection. Furthermore, it is of great interest to observe that the same species of bird was the only one in which two conspicuous and almost certainly distasteful Saturniid moths were found. The *Carabidae* of the genera *Anthia*, *Polyhirma*, *Piezia*, and *Scarites* are not so remarkable. *Scarites* is probably nocturnal and entirely procryptic, while the defensive secretions of the three other genera may be discharged and lost as the result of the attacks of an experienced enemy.

Outside the Coleoptera, the number of birds which ate Pentatomid bugs is remarkable (five species), and it would be interesting if it were possible to obtain the remains and make out the species of these Hemiptera. The specialization of enemies to feed upon forms which have become excessively abundant through specialization in their modes of defence is seen in the two species which contained ants, and the three which had eaten scorpions. The hairy caterpillars eaten by cuckoos are a similar case; this group of birds being specialized to feed on insects which are specially defended against the majority of insect-eaters. The fact that *Phymateus morbillosus*, a large, conspicuous, and strong-smelling locust, had been eaten, is also of interest. *Solpuga marshalli*, in spite of its formidable appearance, is quite harmless, with procryptic appearance and habits. The Tables as a whole afford wonderfully strong support to the existing theories which explain cryptic colouring and instinct as the defence of forms which are eagerly sought for as food by numerous enemies, and an aposematic appearance and mode of life as the defence of specially-protected forms only attacked under the stress of hunger or by comparatively few specially-adapted foes.—E. B. P.]

12. RECORDS OF ATTACKS ON LEPIDOPTERA, ESPECIALLY BUTTERFLIES, BY WILD SOUTH AFRICAN BIRDS. (G. A. K. M.)

[The stimulus which induced Mr. Marshall to collect observations on the attacks of birds upon butterflies was provided chiefly by the account of the discussion which followed Dr. F. A. Dixey's paper on "Mimetic Attraction" (Trans. Ent. Soc. London, 1897, p. 317; Discussion in

Proc. 1897, pp. xx-xxxii, xxxiv-xlvi). The following extracts from a letter indicate the line Mr. Marshall would have taken had he been in England at the time.—E. B. P.]

Malvern, Natal; Oct. 7, 1897.—I am much struck with the large amount of adverse criticism levelled against the theory of even Batesian mimicry. The theory of convergence (Müllerian mimicry) might perhaps be considered as debatable, but how any one who has paid any attention to the subject can doubt the reality of Batesian mimicry, I cannot understand, and the attempt to explain it away by climatic causes seems to me weak in the extreme. If the view, advocated by many, that birds cannot be reckoned among the principal enemies of butterflies in their imago state, be true, then I consider that we may practically abandon the whole theory of mimicry as at present applied to the *Acrwinæ* and *Danainæ* of South Africa at all events, for from what I have observed of these insects I am convinced that their warning coloration cannot have reference to either mantises, *Asilidæ*, or lizards, which are practically the only other enemies that can be taken into account. Moreover, the swift flight of the majority of edible species can only have been developed to enable them to escape from *winged* enemies, and that this development is due to *Asilidæ* or dragon-flies is more than I can believe. Certainly the paucity of records of birds eating butterflies is somewhat disconcerting, but this is doubtless due to the fact that not sufficient attention has been paid to the subject, which would entail long and patient observation of the birds themselves, an occupation that the average entomologist is not likely to indulge in when out collecting. Personally I do not suppose I have seen such an occurrence more than perhaps half-a-dozen times; the birds being the Paradise flycatcher (*Terpsiphone perspicillata*), the bee-eater (*Merops apiaster*), and two rollers (*Coracias spatulata* and *Eurystomus afer*); but then I admit that I have paid little or no attention to the matter until quite recently.

The habits of the *Teracoli*, especially in their winter forms, have always seemed to me strongly suggestive of their being frequently attacked by birds. With hardly an exception they are fairly swift fliers (especially the "purple-tips"), keeping comparatively close to the ground and dodging well. If struck at gently as they fly by, they dodge and hurry onwards but still continue their

flight; if however they be thoroughly frightened by continued strokes of the net, they will dart rapidly on for a short distance, then vanish—or, in other words, they settle with extreme suddenness, and their under-side colouring harmonizes so well with the sandy soil they love that they are very difficult to detect. It seems to me that such a habit can only have been developed for the purpose of escaping from birds, and must be very effectual in most cases. I have noticed that the summer forms, which have not the sandy-coloured under-side do not adopt these tactics, but rely on their flight alone—probably because food is more plentiful for insectivorous birds at that season.

[After this, Mr. Marshall kept a careful record of observations. His results, including one observation made at an earlier date, are shown on pp. 357–9 in the form of a diary. The two following letters bear on the same subject.—E. B. P.]

Salisbury, March 6, 1898.—I was much interested in your arguments* for Common Warning Colours in butterflies and your remarks on their probable enemies, but I must candidly confess that I am not altogether convinced. The difference in our views lies in your fundamental proposition that butterflies are an easy prey for birds to capture from a general point of view. If this proposition be correct, then I quite agree that your theory offers the most natural and probable explanation of the predominance of bright colours among butterflies. But from what I have seen of the South African species I could not truthfully say that I consider that they would be likely to fall an easy prey to birds, indeed I should say that the average insectivorous bird would not have a chance against most of the swift-flying species when on the wing, and would only be able to catch them under exceptionally favourable circumstances when the insects were off their guard. If this supposition be correct it would go a good way to explain how so many butterflies have been able to acquire such brilliant colours, and particularly in the case of those species which have protectively-coloured under-sides, which is the rule rather than the exception. Birds would soon learn the futility of attempting to *pursue* such species, and would only capture them by stealth, and in a more or less

* Some of the arguments here referred to are set forth on pages 500 to 502 of the present memoir.—E. B. P.

unobtrusive manner, which might account for the paucity of records. The fact that birds have been seen to capture moths more frequently than butterflies need not necessarily imply a preference for the former insects, but might be explained on the supposition that they are aware that they can be captured more or less easily on the wing, and therefore that when a moth does happen to get well up into the air in open country it is promptly pursued, whereas under similar conditions a butterfly would be allowed to pass unmolested. While on the subject of swift flight I might mention that I was much struck during my visit home with the *slow* flight of English butterflies as compared with the generality of South African species. I am inclined to agree with Trimen in his Presidential Address to the Entomological Society, that birds are among the chief enemies of butterflies. That they have been the chief, if not the only, agents in the production of mimicry, whether Batesian or Müllerian, I have little doubt. It is highly significant that mimicry in its fullest development is only to be found in forest-clad regions where insectivorous birds are most abundant. Moreover, I am not aware of a single instance of true mimicry among species which *habitually* settle on the ground.

Salisbury, March 10, 1898.—It would seem that mere unpleasantness of taste or smell would hardly be sufficient to give so great an immunity from attack from birds as is apparently enjoyed by the *Danaïnae* and *Acræinae*, unless accompanied by poisonous or unwholesome qualities—at least, if we may judge by other orders of insects. A large number of Rhynchota, for instance, possess a very unpleasant smell, and yet their colouring is procryptic instead of aposematic. In the crop of the great spotted cuckoo I have found a large green Pentatomid, which in the strength and unpleasantness of its smell is only beaten by *Petascellus remipes*, our largest Hemipteron. Again, in the crop of the racquet-tailed roller (*Coracias caudata*, Trim.) I have found a full-grown specimen of a large *Phymateus* locust, which is a most evil-smelling beast. This insect appears to combine procryptic and aposematic colours; for when settled its general green colour is eminently protective, but during its laboured flight it is most conspicuous owing to its brilliant crimson and purple hind-wings. If annoyed when settled on the ground they often raise their wings over their backs (clearly to exhibit

the bright colours), exuding at the same time an odoriferous frothy liquid from the thorax.

1897.

- March 28. While out collecting at Malvern, Durban, Natal, I saw a Paradise flycatcher (*Terpsiphone perspicillata*) catch a specimen of *Eronia cecodora*. The butterfly was hovering over a flower when the bird swooped down, seized it *with its feet*, and carried it off.

1898.

- Feb. 27. Saw a Marico wood-shrike (*Bradyornis maricensis*) dart down from a tree and catch a *Sarangesa eliminata* (Holl.), which was sitting with outspread wings on a small plant.
- March 6. Saw a flycatcher (*Pachyprora molitor*) make several futile attempts to catch a *Tarucus plinius* which was circling round the bush on which it sat.
- Nov. 23. Saw a bush kingfisher (*Haleyon chelicutensis*) catch and eat two butterflies, viz. *Junonia cebrene* and *Catopsilia florella*, both of which were captured when feeding.
- Dec. 1. C. F. M. Swynnerton saw a drongo (*Buchanga assimilis*) fly past him with a white butterfly in its beak, probably *C. florella*.
- „ 15. Remains of *Papilio demodocus* found in the stomach of a cuckoo (*Coccytes caffer*).

1899.

- Jan. 1. While watching an *Atella phalantha* hovering over a bush of its food-plant, a Paradise flycatcher (*Terpsiphone perspicillata*) darted past, and with a loud snap of its beak tried to catch the butterfly in its swoop. The latter escaped, however, and on following it up I found that the tip of one hind-wing had been cut clean off; unfortunately I had no net and failed to capture the insect.
- Swynnerton shot a hobby (*Falco subbutco*), which had in its stomach an almost

complete *Terias*. The thorax and abdomen were quite uninjured, but the tips of the fore-wings were gone.

- April 26. I was watching a drongo hawking insects from the top of a dead tree; there were many *Picrinæ* about, chiefly *Teracolus* and *Belenois*, but the bird paid not the least attention to them. At last a *Belenois* came by which had its wings very much shattered, so that its flight was weak and erratic; the drongo observed it at once, and swooped down on it, but I saw the butterfly drop into the long grass. Whether it was injured by the bird I could not say, as I was unable to find it, and I did not see it rise again. This episode would point to the conclusion that the fact that birds refrain from pursuing butterflies may be due rather to the difficulty in catching them, than to any widespread distastefulness on the part of these insects.

1900.

C. F. M. Swynnerton wrote from Gazaland: "In March [1900] I saw a *Pratincola torquata* [South African stonechat] in chase of *Tarucus plinius*. Had it not been frightened off by coming face to face with me, it would undoubtedly have caught it. I think I told you long ago of having found the wings of a lot of butterflies, chiefly *P. corinnus*, below the branch of a tree on which some swallows were constantly settling."

- May 13. Salisbury. Saw a drongo (*Buchanga assimilis*) swoop from a tree and catch, what I took to be an injured *Belenois*, which it dropped almost at once. I marked the insect down, and found it to be a common white moth of the distasteful genus *Diacrisia* (*D. maculosa*).

1901.

- Dec. 17. Melsetter, 5500 feet, Gazaland. A specimen of the large, conspicuous, Hypsid

moth *Callioratis bellatrix* was seized and rejected by a drongo, undoubtedly a young bird, judging by its plumage. [The moth, which is now in the Hope Department, has lost most of the head, but is otherwise uninjured.—E. B. P.]

13. RECORDS OF ATTACKS ON BUTTERFLIES BY WILD BIRDS IN INDIA AND CEYLON, BY COLONEL J. W. YERBURY, R.A.

[Colonel Yerbury has kindly extracted from his notes all the observations he has made bearing on this interesting question.—E. B. P.]

“About the year 1884 a discussion arose in the Bombay papers as to whether birds preyed on butterflies, and the general opinion expressed was that it was comparatively rare for them to do so. In common with some other members of the Bombay Natural History Society, I determined to watch and note the results. My records taken from old diaries are as follows:—

1884.

Neighbourhood of Poona and Aden. None.

1885.

Sept. 23. Aden, Campbellpore, and Murree Hills. Road up Thundiani, near the Kala Pani Bungalow. Saw a young king-crow, *Dicrurus ater*, stoop at a big blue *Papilio*, either *P. polycctor* or *P. arcturus*, and miss it. The bird did not repeat the attempt.

1886.

Sept. 2. Campbellpore, Thundiani, etc. Road up Thundiani, near top of the hill. Saw a young king-crow stoop at a specimen of *Vanessa kashmirensis*, and after missing it once take it at the second attempt. Did not notice whether the insect was eaten.

1887.

Rawul Pindi and home, *viâ* Japan and America. None.

1888-9.

At home.

1890.

June. Ceylon, Trinkomali. No record.

1891.

Nov. 14. On the Kandy Road between Trinkomali and Kanthalai; butterflies in great numbers sitting on the wet mud by the roadside; chiefly *Pierinæ* (*Catophaga*), but a few *P. nominus* with them. These butterflies rose in clouds as one drove past. A bee-eater, *Merops philippinus*, kept flying in front of my carriage and taking specimens of these butterflies as they rose. The bird seemed to select the yellow females, which are rare, the white females being to them probably in the proportion of 100 to 1. These flocks of butterflies often unite and form what are known as snowstorms in Ceylon; they then migrate right across the island.

"These bee-eaters were often seen catching *Pierinæ*; in fact, it seems to have occurred so often that I ceased to record the fact, for I can only find this one reference. Probably the attacks were always witnessed at the beginning of the N.E. monsoons during the time of the heavy rains, *i. e.* September to December.

"I am not certain as to the date on which I saw the Ashy swallow-shrike (*Artamus fuscus*) catching specimens of the Euplœa *Crastia core*. The fact is associated in my mind with a particular place, and with the capture of *Charaxes psaphon* ♀ there. This is recorded for April 12th, 1891, so this may be the correct date on which I watched the bird. At least six specimens of the *Crastia* were captured by the shrike, all of which it carried away to a branch high up in a big tree, but I could not see whether they were eaten.

"As regards my experience of birds catching butterflies, it appears to have occurred more frequently in damp than in dry districts; *e. g.* it was frequent in Ceylon, rare in

places with moderate or small rainfall, such as Campbell-pore, Poona, and Aden.

"In my opinion an all-sufficient reason for the rarity of the occurrence exists in the fact that in butterflies the edible matter is a minimum, while the inedible wings, etc., are a maximum."

[See Proc. Zool. Soc. 1887, p. 210, where Lepidoptera and especially butterflies are spoken of in almost exactly these terms, as a suggested explanation of the fact that lizards, although they eat them, greatly prefer flies or cryptic larvæ.—E. B. P.]

14. RECORDS OF ATTACKS ON BUTTERFLIES, ETC., BY
WILD BURMESE BIRDS, BY COLONEL C. T. BINGHAM.

[Colonel Bingham has kindly sent me the following extracts from his 1878 diaries, for incorporation in the present memoir.—E. B. P.]

"April 23.—Marched from Kawkaraik to Thinganyinaung, fourteen miles. Started about 7.45, rather late as there was some difficulty in collecting the elephants this morning. . . . The road, a mere jungle path, followed the course of the Akya Chaung, a feeder of the Haundraw River, and crossed the little stream some twenty or more times in the first six or seven miles before turning up the hill to the Taungyah Pass in the Dawnat Range. From the outskirts of Kawkaraik right up to Thinganyinaung on the other side of the pass, the road goes through dense evergreen forest, and consequently the collecting is very good on this road, both for insects and birds. To-day, the day being hot, butterflies, bees, and dragon-flies swarmed, and at every opening of the Chaung I found crowds seated on the damp sand apparently sucking up the moisture. Collecting as I went, it was past 11 o'clock before I got to the foot of the Pass. I was hot and a bit tired, so I sat down on a fallen tree to rest, just before crossing the Akya Chaung for the last time. I had not been seated many minutes looking at the swarms of butterflies, bees, and dragon-flies, which were flitting about or sitting on the sands, when my attention was attracted by a bird, a bee-eater (*Merops swinhoei*), which swooping down from a tree overhead caught a butterfly, a *Cyrestis*, within a few paces of me. The bee-eater seemed to catch the butterfly with ease, and I distinctly heard the snap of its bill. Then holding the butterfly crossways the bird flew back to the

tree, and sat still for a minute or so, then came a little jerk of the head, and the wings of the butterfly came fluttering to the ground, while the body was gulped. On the same branch some four or five more bee-eaters of the same species were seated, and as I sat very still, one after another these birds swooped close to me, sometimes after a butterfly, sometimes at a bee or a dragon-fly. More than once I saw a bird miss a butterfly, when the latter would dodge and try to get away among the bushes of the dense undergrowth around, but only very seldom was this successful, for the bird would hover and twist and turn in hot pursuit, and generally managed to catch the insect. I was greatly interested, for though I had seen both bee-eaters and king-crows (*Dicrurus*) go for butterflies and moths, this was the first time I had witnessed a continuous hawking of butterflies on the part of birds. I sat for nearly half-an-hour watching. The birds seemed to swoop only for the insects flying about, never at those on the ground. A drove of pack bullocks with their shouting Shan drivers coming down the road frightened the bee-eaters, and they flew off. I got up and prepared to start up-hill, when it struck me that it would be interesting to see what species of butterfly had been taken by the bee-eaters, so I set to work and collected all the loose wings I could find. I did not get many, for the undergrowth was very dense, and the wings dropped in it were difficult to find. Also the place swarmed with ants, I could see them on all sides carrying off whole wings, or portions bitten out of them. Again I was pressed for time, so that I managed to get together only nineteen wings, most of them odd ones luckily. . . . I have just sorted out and put away my collections of the day. The butterflies hawked and eaten by the bee-eaters belong to the following species—*Papilio erithonius*, *P. sarpedon*, *Charaxes athamas*, *Cyrestis thyodamantus*, and *Terias hecabe*. A meagre list, for I am certain I saw the bee-eaters swoop for and catch *Prioneris*, *Hebomoia*, *Junonia*, and *Precis*. I also particularly noticed that the birds never went for a *Danaïs* or *Euplœa*, or for *Papilio macareus*, and *P. xenocles*, which are mimics of *Danaïs*, though two or three species of *Danaïs*, four or five of *Euplœa*, and the two above-mentioned mimicking *Papilios* simply swarmed along the whole road.” *

* I did not then realize the importance of my find, or I should have spared more time for the collection of the fallen wings of the butterflies, and taken more care of them.—C. T. B.

Looking through my diaries I find more scattered notes of my having witnessed birds swoop for and catch butterflies and moths, but these were solitary incidents, and only slight mention is made of them in the diaries with one exception, which is given below—

"*Camp Wabosukhan*, December 3. . . . Going through some fairly open jungle close to the main road I put up a *Melanitis zitenius*, which fluttered across the road and was swooped at by a king-crow (*Dicrurus*) but missed; the butterfly dodged, got to the other side of the road and dropped to the ground among the herbage and fallen leaves, as is the habit of *Melanitis*. The king-crow hovered for a minute not three feet from the ground over the exact spot where I had noticed the butterfly drop, failed to see it, flew off, but returned and again hovered over the spot, but was again unsuccessful, and flew up to a tree. I went forward very cautiously, and having carefully noted the spot where the butterfly had dropped, was enabled to make it out, but not till after fully ten minutes of patient and very cautious looking. The *Melanitis* was there among dead leaves, its wings folded and looking for all the world a dead dry leaf itself. With regard to *Melanitis*, I have not seen it recorded anywhere that the species of this genus when disturbed fly a little way, drop suddenly into the undergrowth with closed wings and invariably lie a little askew and slanting, which still more increases their likeness to a dead leaf casually fallen to the ground.

"Only once again did I see the systematic hawking of butterflies by birds. This second occurrence was also by bee-eaters; this time it was the large *Merops philippinus*. I had been up in the Salween forests beyond the great rapids, and had managed to get a bad bout of fever which necessitated my returning to Moulmein, my head-quarters. It was a hot steamy day in October, and I was lying with the hot fever fit on me in the boat on the Salween below Shwègon, when I noticed clouds of butterflies, chiefly *Catopsilia*, migrating, crossing the Salween from east to west in a continuous stream. These were being persistently hawked by the *Merops*, mixed with which were some king-crows."

With regard to *Microhierax corulescens* catching butterflies, I find the following note:—

"*March 20, 1881.* . . . Passing through a taungyah on my way back to camp I noticed a number of butterflies,

some seated, some hovering round a spot where some Karens had been eating their food, and had left some rice and gnapi scattered on the ground. I was approaching the butterflies cautiously to see what species were there, when a small black-and-white bird came down from a tree close by and perched on the ground close to one little mob of butterflies busy feeding away on the gnapi. I recognized the bird at once as the pigmy hawk (*Microhierax caerulescens*). His coming flop down close to the butterflies disturbed some, but not all. A few were too intent on their meal. The hawk sat for fully two minutes looking at the butterflies, then he crouched as birds do when they are about to rise, and next moment with a quick snatch he had taken a butterfly in his claws and was flying to the nearest tree. Though I was watching intently I am quite unable to say whether he took one of the sitting butterflies or one that was flying about. I watched him eat the insect, which he held with his claw against the branch on which he was seated, and he tore at it just as the larger hawks do with their prey. I wanted a specimen of the bird, so shot it, and afterwards picked up the wings of the butterfly he had eaten; it was a *Papilio sarpedon*."

N.B.—That same specimen of *Microhierax* is now, I believe, in a small case by itself in the bird gallery of the British Museum.

[Colonel C. T. Bingham has also made some interesting observations on the use of insects' wings as a pad at the bottom of a hole in a tree, forming the nest of this same species of bird, the falconet *Microhierax caerulescens*, Linn. (*M. cutolmus*, Hodgs.). The following account is quoted from "Stray Feathers" (vol. v, No. 2, June 1877, pp. 79–81). The observations were made in the "Government Teak Reserve on the Sinzaway Chaung, a feeder of the Yoonzaleen River, which it enters about two days' march below our frontier station of Palpooon in Tenasserim." The nest was found on April 14, "in a hole on the underside of a decayed bough of a mighty Pymma tree (*Lagerstræmia Flos Reginæ*)." The four eggs were found to be "stained by resting on the broken leaves, wings of dragonflies, and bits of wood which composed the nest." The editor appends to this account a note of Davidson's which had been in his possession for years. On March 25 the nest of *Microhierax fringillarius*, Drap., was examined. It had been made in a hole in a dry tree in an old taungyah (clearing) "near Bankasoon at the extreme south of Tenas-

serim." "At the bottom of the hole, which was about eighteen inches deep, was a soft pad composed of flies and butterflies' wings, mixed with small pieces of rotten wood."

In March 1878, Col. Bingham found a second nest of the same species (*M. carulescens*) which he sent to the late Mr. de Nicéville in order to ascertain the species of insects which had been made use of. Mr. de Nicéville wrote as follows:—

"The fragments of butterfly wings you send are as follows:—

- No. 1. Portion of fore-wing of *Papilio caunus*.
- „ 2. Fore- and hind-wing of *Mycalesis perseus*.
- „ 3. Hind-wing of *Papilio erithonius*.
- „ 5. Portion of fore-wing of *Junonia orithyia*.
- „ 4, 6, 7, 8, 9, too fragmentary to make out, but seem to belong to some species of the *Lycenidae*.
- „ 10. Half of fore-wing of *Charaxes* sp. ?.
- „ 11. Portion of hind-wing of *Symphædra dirtea* ♀.
- „ 12 to 17 are the wings of dragon-flies.*

A passage from another letter of Mr. de Nicéville to Colonel Bingham indicates in a different manner the severity of the nearly unseen struggle for existence which butterflies of certain genera pass through. The wings sent by Col. Bingham were found by him in 1888. Mr. de Nicéville wrote concerning them:—

"See p. 275 of vol. ii of my 'Butterflies.' Ferguson found a single wing of *Charaxes schreiberi* in Travancore on the ground. It is curious that the only record so far of the

* In the *Zoologist* (4th Series, vol. v, 1901, pp. 224, 225) Colonel Bingham states that he found, on April 23, 1899, a nest of the same species of pigmy falcon in a hole on the under-side of a branch of a dead tree in a deserted taungyah alongside the high-road leading from Thabeitkyin, on the banks of the Irrawaddy above Mandalay, to Mogok, the site of the famous Ruby Mines of Upper Burma. The hole had evidently been made by a Barbet. It was 15 inches long, and at the end was slightly enlarged into an oval chamber containing "a fairly firm pad of chips of wood, a few leaves, with an upper stratum quite two inches thick, composed almost entirely of the wings of cicadas, with a few butterfly and moth wings interspersed therein." There were no eggs or nestlings. "Further south, in Tenasserim," Colonel Bingham continues (l.c. p. 225), "I found the eggs of this falcon in a precisely similar situation early in April, as well as I can remember. That nest was composed almost entirely of butterfly wings." Colonel Bingham informs me that the last-named nest was the one, described above in the text, which was found in March 1878, and furnished the wings named by de Nicéville.

same species from Burma should be the three wings you send me, which you say you found on the ground."—E. B. P.]

15. GUY A. K. MARSHALL'S INDIRECT EVIDENCE OF THE ATTACKS UPON BUTTERFLIES. (E. B. P.)

At the meeting of the Entomological Society held on August 1, 1883, Professor Meldola communicated some observations made by Dr. Fritz Müller in Brazil (Proc. Ent. Soc. Lond., p. xxiii), together with specimens of distasteful conspicuous butterflies with wings notched or otherwise injured apparently by birds. Dr. Fritz Müller's well-known theory, which accounts for synaposematic resemblances, implies that even distasteful butterflies are experimentally attacked by young enemies. That such attacks are made had been doubted, and Professor Meldola therefore wrote to Dr. Müller asking him to collect observations upon the point. A specimen of *Heliconius eucrate* sent by him to Professor Meldola was described (Ann. Mag. Nat. Hist., Dec. 1882, p. 419) as having a symmetrical, jagged notch on both fore-wings, and on Aug. 1, 1883, Professor Meldola exhibited examples of thirty-six notched and shorn specimens of *Acraea* [*Actinote*] *thalia*, obtained in one week by the great German naturalist. These examples and the *Heliconius* have been presented by Professor Meldola to the Hope Department, where they may be seen beside numerous similar specimens from very different parts of the world, including those figured on the accompanying Plates IX, X, and XI. Similar observations upon Bornean butterflies, including four *Danainæ*, have been published by S. B. J. Skertchley (Ann. Mag. Nat. Hist. (6) iii, 1889, pp. 477–485), while W. L. Distant has described unsymmetrical injuries, apparently caused by a bird, in the wings of *Limnys chrysippus* ("Naturalist in Transvaal," 1889, p. 65). I noticed the same thing (1888) in many specimens of *Colias edusa* captured in Madeira ("Colours of Animals," London, 1890, p. 206; see also Roland Trimen's Presidential Address to the Entomological Society of London, Jan. 19, 1898, where many of these and other records are collected and commented upon).

It seemed of importance to obtain this kind of evidence from as many parts of the world as possible and on a large scale. I therefore asked Mr. Marshall if he would kindly

look out for specimens of butterflies bearing injuries which were probably caused by birds or other enemies. The results, as in every other instance in which I have asked for his help, far exceeded my most sanguine hopes. He sent me the fine series of injured specimens represented on Plates IX, X, and XI.

Looking at the species represented in this collection one is at once struck with the repetition of the very forms which have been seen to be attacked by birds (see pp. 357 to 359). Thus *Atella phalantha*, once seen to be mutilated by a bird (p. 357), is represented by no less than five injured specimens (Plate IX, figs. 9 and 12; Plate X, figs. 2, 4, and 5). And nearly every other species observed to be attacked or found in the stomach of a bird is also represented, often by two or more examples, in the three accompanying plates.

The presence of specially-protected forms, *Danaïnx* and *Acræinæ*, is as conspicuous as in the observations made in other parts of the world; but new and interesting light is thrown upon the problem by the examination of these specimens and comparison with those of other more palatable groups. A large proportion of the former (Plate IX, figs. 1, 5, 7, 10, 11) are far more extensively mutilated than any but exceptional instances among the latter, and remarking the peculiar toughness, flexibility, and power of recovery in the wings of *Danaïnx* and *Acræinæ*, we are driven to the probable conclusion that the results are in many cases those of experimental trials by young enemies and heroic attempts on the part of extremely hungry enemies, rather than unavailing efforts at the capture of palatable prey. The futile attempts of hungry animals, accompanied by extensive mutilation of unpalatable insects, are well known in confinement (Proc. Zool. Soc., 1887, p. 191), and Mr. Marshall has made observations of the same kind upon insect enemies in the wild state (see pp. 318, 358, 359).

The conclusion that butterflies may be pursued when specially easy to catch, suggested by the observations on April 26, 1899 (p. 358), is somewhat confirmed by the curious fact that all the five examples of *Limnas chrysippus* are females (Plate IX, figs. 1, 5, 10, and 11; Plate X, fig. 1).

Of the conspicuous wet phases of the seasonally dimorphic *Precis* only a single example is present (Plate IX, fig. 24),

whereas six examples of the cryptic dry phase are included in the series (Plate IX, figs. 15, 19, and 23; Plate XI, figs. 1, 2, and 4). These facts may possibly lend some support to the suggested interpretation of these remarkable changes (see pp. 431 to 442).

Some naturalists may be inclined to interpret the injuries represented on Plates IX, X, and XI as the ordinary results of age and wear, or the accidental contact with thorns or twigs. Such an explanation is not consistent with the fact that the great majority of the specimens are in other respects fresh and unworn, and the margins of the wings not frayed as they become in individuals which have been long upon the wing. Again, the very high proportion of the injuries inflicted at the anal angle and along the hind margin of the hind-wing is inconsistent with any such interpretation. The part of the wing surface which is certain to come most in contact with foreign objects is the apical angle of the fore-wing, next, the costal and hind margins of the fore-wing, last of all the border of the hind-wing which is behind, and, as the insect finds its way through an interlacing meshwork of twigs and leaves, is defended by the greater width and powerful costa of the fore-wings. It is true that the apex of one or both fore-wings is not uncommonly snipped off, several examples being represented on Plate IX, and in the four lowest figures on Plate XI, but the great majority of the specimens captured by Mr. Marshall will be found to be injured in the hind-wing. And of those snipped or notched in the fore-wing, some exhibit symmetrical injuries which clearly suggest that the insect was seized with the wings together, probably at rest. Figs. 12 and 17 on Plate IX are good examples. Equally symmetrical injuries are also common on the hind-wings, either taking the form of a snip which suggests the very shape of a bird's bill (*e. g.* Figs. 4, 30, 31, 33 on Plate X), or one in which both anal angles or even a large part of both hind-wings are shorn completely off (*e. g.* Figs. 2 and 28 on Plate X; Figs. 8, 9, 18 and 20 on Plate XI).

In one very interesting example of *Vanessa atalanta* from N. Devon, presented by Dr. F. A. Dixey to the Hope Department, there is only one possible position in which the injury could have been inflicted, viz. the position shown in Fig. 31, Plate X, for in that position alone can the snip *in all four wings* be made to coincide. Furthermore, the position is that of complete repose, when the

white patch on the costal border of the under-side of one hind-wing, wrapping round the front of the costa of the fore-wing, meets the corresponding patch on the opposite side, and is distinctly seen from the front. The specimen captured by Mr. A. H. Hamm, represented in the adjacent Fig. 33, was probably seized soon after it had alighted, when the wings were held in the manner indicated in the figure, and before they were lowered between the hind-wings in the attitude of repose. Or it is possible that this specimen was seized during flight at the moment when the wings came together.

The theory of probability prevents the interpretation of any but very rare symmetrical notches, except on the supposition that the wings were together at the time of the injury, and when the condition of the specimen is fresh and the notch possesses a definite and similar shape, fitting that upon the opposite side, there can be no hesitation in inferring the attack of an enemy.

Turning to unilateral injuries, of which many examples will be found in Plates IX, X, and XI, Mr. Marshall is of opinion that they are the strongest evidence of the attacks of birds because they were almost certainly inflicted while the insect was upon the wing. Perfectly fresh specimens with such injuries of a very pronounced type are shown on Plate IX, figs. 15, 19, and 23; Plate X, figs. 1, 3, 5, 19, 25, 29, etc.; Plate XI, figs. 4, 6, 7, 11, etc. It is true that a butterfly settled upon a flower with outspread wings might be seized by one side; but insects in that position are on the alert, and many butterflies when slightly disturbed will shut their wings with a snap when they do not take flight.

Looking at the injuries as a whole it is seen that the great majority are inflicted at the anal angle and adjacent hind margin of the hind-wing, a considerable number at or near the apical angle of the fore-wing, and comparatively few between these points, at or near the inner angles of the wings. I was at first greatly struck by the comparative rarity of injuries in the last position, but in a later consignment Mr. Marshall forwarded many excellent examples, referred to in the following paragraph:—

"*Salisbury, Sept. 27, 1901.*—It was curious that just after getting a letter from you, pointing out the greater rarity of mutilation at the inner angles, I came across quite a succession of excellent examples of this form. The

Teracolus omphale is of special interest, as I think the attack can only have been made by a bird. The same applies to the *Nyctemera*, for this insect invariably conceals its hind-wings when settled, dropping immediately into this position as it alights. I have occasionally observed that it holds its wings over its back for a very short time before closing them. I think the damage to the hind-wings must be the result of two separate snaps from a bird while the moth was on the wing."

The specimen of *Teracolus omphale* was accidentally omitted from the illustrations, but the *Nyctemera* is shown on Plate X, fig. 8, and three of the best examples of injury at an inner angle on Plates IX, figs. 15, 19, and 23.

If it be granted that the injuries shown on Plates IX, X, and XI are chiefly if not entirely due to enemies, the question as to the kind of enemy remains to be settled. The only probable foes are birds, reptiles, especially lizards, and mantides. It is therefore of importance to show that injuries entirely similar in character to those upon Mr. Marshall's South African captures, are also found on butterflies from parts of the Holarctic Belt where mantides do not exist and the attacks of lizards amount to so little that they may be safely neglected.

I have therefore included (on Plate X, figs. 26 and 28 to 33) the representation of a few butterflies with snipped wings from the Northern United States, Switzerland, and England. These are only a selection from a much larger amount of material of this kind in the Hope Department, but sufficient to show that the character of the injuries in the northern land belt is the same as that of those far south of the Equator, and in a country where lizards and mantides are very important foes.

Much however may be determined by the character of the injury and the habits of the butterflies. Such an injury as that shown on Plate X, fig. 4, for example, is hardly likely to have been caused by anything but the beak of a bird. When a mantis seizes a butterfly with its raptorial legs the wings are instantly crumpled and at the same time torn and scratched with the thorn-like spines. Only two or three specimens out of the 82 here figured bear any such traces, viz. Plate I, figs. 7, 11, and Plate XI, fig. 5, and in these cases the interpretation is very far from certain. With regard to lizards, butterflies which settle on low flowers, and especially those which alight

on the ground and rocks, are very liable to be attacked, but in South Africa at least, species which haunt bushes and trees and fly high are not likely to fall a prey to lizards, and birds are the only probable enemies when no traces have been left by a mantis. In the description of Plates IX, X, and XI, a brief account of the habits of each South African species is given by Mr. Marshall together with the conclusion which appears to be justified.

A very interesting general conclusion emerges after this consideration and comparison of all the specimens here figured, viz. the bionomic meaning of important elements in pattern, and important structural developments of the wings of Lepidoptera. On Plate IX we see evidence that injury at the apical angle of one or both fore-wings is fairly common. Now this angle is very remote from the vital parts, and no great harm to the butterfly is done by such injury. And this is a part of the wing which is constantly rendered specially conspicuous below as well as above by apical and sub-apical white spots and bars, black tips, patches of bright colour, and by eye-spots (Plate IX, figs. 1, 3, 15, 16, 20, 21, 22, 23, 25; Plate X, figs. 3, 8, 19, 25, 28, 32, 33; Plate XI, figs. 4, 21, 22, 23, 24). In the four lowest figures on Plate XI the conspicuous apical marking has been injured and, in three cases out of four, partially or entirely shorn off on one side. This interpretation of the meaning of the apical colour-patches was suggested by Mr. Marshall in sending these very specimens, and he alluded to two out of the three butterflies figured on Plate XI, figs. 21-23, in the following passage:—

“*Salisbury, June 20, 1899.*—I would suggest that these bright patches of colour [in the orange- and purple-tipped *Teracoli*], which were doubtless first developed by sexual selection, have been of further use in diverting attack from the vital parts, and this may perhaps explain their almost universal transmission to the female sex. I have sent you two good examples supporting this view, in that the orange tip of one wing has been snipped off, presumably by a bird. It should however be noted that the *purple* tips are very inconspicuous in flight, and perhaps this might account for the markedly-swifter flight of those species which possess them, as they will have thus lost a useful protection through the action of sexual selection, and have compensated it by increased swiftness.”*

* Dr. F. A. Dixey points out to me that it is in favour of this

Notches close to and sometimes involving the same kind of markings are to be seen on Plate IX, figs. 1, 3, 5, 10, 16, 19, and 21.

We can thus understand the conspicuous apical markings of the fore-wings of butterflies, together with the common prolongation of the apex of the wing, as directive marks which tend to divert the attention of an enemy from more vital parts.

The comparison of Figs. 31 and 33 on Plate X will show a common method in the use of this marking on the under-side. It is exposed for a few seconds after the butterfly alights (Fig. 33), and then hidden by lowering the fore-wings between the hind (Fig. 31). The meaning is no doubt that which is suggested on pp. 440, 441, where it is however applied to the case of those sub-apical eye-spots on the under-side (Plate X, figs. 28 and 32) which are exposed and then hidden in a similar manner.

Since the above sentence was written I have consulted my assistants, Mr. W. Holland and Mr. A. H. Hamm, who have had great experience in the ways of British Lepidoptera, and they both agree with me that our species of *Satyrinæ* with special sub-apical eye-spots on the under-side of the fore-wing are apt to expose these marks for a few seconds after alighting, and then swiftly cover them by lowering the fore-wings between the hind. The "Grayling," *Satyrus semele*, is particularly noticeable in this respect, as all three of us have often observed; but the movement is well seen in our other species with similarly-placed eye-spots.* This characteristic movement considered in relation to Mr. Marshall's injured specimens, and to the experiment with a lizard mentioned on pp. 440-1, and a kestrel on p. 341, places the hypothesis advanced on the former pages in a satisfactory position.

But the interpretation of markings and structures at or

interpretation that the *females* of the species with purple-tipped males are themselves often orange-tipped.

* Dr. Dixey has specially observed this movement in *semele*. He states that *Epinephele javira*, on the other hand, usually shows the eye-spot when resting by day, although it quite conceals it when settling down in the evening: while a ♀ *E. lithous*, settled on a bramble-leaf in sunshine, exposed the ocellus, but concealed it when a cloud came over the sun, again uncovering it when the cloud passed. Dr. Dixey's notes were made at the time of the observations at Morthoe, North Devon, in 1897-8.

near the anal angle of the hind-wing is even more convincing, inasmuch as both markings and structures are far more specialized and examples of their injury much commoner. Plate X is entirely occupied with the representation of such injuries in species which are without special directive marks and structures at this region of the hind-wing, while Plate XI, with the exception of the four lowest figures (21 to 24) and figure 4, is devoted to the illustration of injuries received at the very spot which has been rendered specially conspicuous. In fact, on Plate IX we have evidence that the attacks of enemies are common at the apical angle of the fore-wing, and on this Plate as well as in the four lowest figures of Plate XI the special directive marks developed at this specially-exposed area are seen to be shorn off or in some way injured; while on Plate X we have the same kind of evidence of still more frequent attack at the anal angle of the hind-wing, together with, on Plate XI, the evidence that this general tendency on the part of the enemy is encouraged by the development of directive features of all kinds, which are shown to be successful in that they have been attacked. We see on Plate XI the prolonged "tails" of the hind-wings of *Precis* shorn off (Fig. 1), together with the large eye-spot marking the same region in *Papilio demodocus* (Figs. 8 and 9), the two "tails" of *Charaxes* (Figs. 5, 10, 13, 14, 15, 20), the slender single "tail" with its accompanying single or double eye-spot of some *Lycanida* (Figs. 6, 11, 16, 17), the conspicuous lobes combined with one or two "tails" and bright spots, sometimes in the form of eye-spots, of other *Lycanida* (Figs. 3, 7, 12, 18, 19).

Many beautifully "tailed" forms occur among the *Nymphalinae* of tropical America, such as *Protoparce*, *Anax*, etc., and the commonly developed "tails" of *Papilio* are probably to be explained in the same manner. When a "tail" is produced at the anal angle of the hind-wing in relation to a dead-leaf-like under-side, the mid-rib-like stripe is developed in relation to the apparent leaf stalk, as is seen in Plate XIII, figs. 4a, 4b, 6, 7, and 8. On the other hand, Fig. 1 on Plate XI shows well that such "tails" may also act as advantageous directive structures.

The resemblance of the marks and structures at the anal angle of the hind-wing under-side in many *Lycanida* to a head with antennæ and eyes has been independently noticed by many observers. The movements of the hind-

wings by which the "tails," the apparent antennæ, are made continually to pass and repass each other, add very greatly to this resemblance. The head-like appearance, first observed by Dr. Arnold in *Thecla iarbas* and confirmed in other species by Dr. Forsströna, is quoted by Kirby and Spence (People's Edition, 1867, p. 423): it was independently observed by Mr. R. C. L. Perkins ("Colours of Animals," London, 1890, p. 208) in *Thecla W-album*, and this keen naturalist obtained confirmatory evidence in the case of the English *Thecla*, similar to that shown upon Plate XI. My friend Dr. Richard Evans of the Museum at Georgetown, British Guiana, independently observed the same thing in Siam, when taking part in the Skeat Expedition. My friend Professor Wyndham R. Dunstan, F.R.S., sending me a pair of *Deudorix antalus* bred from larvæ which are destructive to the pods of "*Inga dulcis*" at Manashi, near Cairo, wrote (July 4, 1900) that his friend Mr. E. A. Floyer who sent the insects "remarks that the butterfly has markings on its tail which resemble the head. He considers this protective, as a bird is uncertain which is the head and which is the tail, and the insect often escapes by going off in the unexpected direction." My friend Mr. Champion B. Russell, who presented to the Hope Department the beautifully mutilated specimen of *Spindasis natalensis* represented on Plate XI, fig. 3, also independently recognized the same resemblance (1900), and thought that the lobes with their two tails passing and repassing each other looked like jaws opening and shutting. I asked Mr. Marshall's opinion on this subject and received the following reply:—

"Salisbury, June 11, 1901.—Mr. Russell's observations on the tails of *Lycænidæ* are, as you say, of considerable value as coming from an entirely independent source, but I must confess that I am not inclined to believe that the anal appendages in the wings of butterflies have been modified in imitation of particular organs, for I fail to see how this could be effected by ordinary selection. And I think a valid argument against such an idea is the great diversity of form shown by these appendages, not only among the *Lycænidæ* but other families as well. It seems safer to regard these curious lobes and tails as having been developed by natural selection for the purpose of attracting attention to that part, and that the particular form they take is due to congenital variations which we cannot

at present explain. As a matter of fact there seem to be really very few "blues" in which the tails bear any real resemblance to antennæ. Again, so far as the special explanation of jaws is concerned it seems to me that this would rather prompt a bird or lizard to attack the insect at the other end, which would be fatal. In some cases there appears to be a possibility of explaining the particular shape of a tail; for example, in *Charaxes* the general rule is two thin tails on each wing, and we can understand that this would not be suitable for the leaf-like under-side of *C. varanes*, which has consequently developed a single thick tail which is more in keeping with its style of coloration. Again, the thick twisted tail of *Myrina* greatly enhances its general resemblance to a bit of shrivelled fig-leaf, and so forth."

I think, however, that it is probable that such resemblance as there is to a head, in certain species of *Lycænidæ* may be of value and may have been produced by direct selective action, and I would specially draw attention to Mr. Floyer's suggestion (p. 374) that the butterfly may dart off in a direction which the head-like appearance has caused to be unexpected by an enemy. Many years ago my friend Dr. A. C. Haddon, F.R.S., showed me a specimen of a little yellow fish, about $1\frac{1}{4}$ inches long, which he had observed and captured among coral, Aug. 11, 1888, at Thursday Island, Torres Straits. The head was crossed by a dark, white-bordered, vertical, somewhat curved band, which included the eye and tended to conceal it. At the root of the tail was a very conspicuous eye-like mark. The fish had the habit of often swimming for a little distance very slowly tail first, but if disturbed it would dart off with great rapidity in the opposite direction, viz. head first. That so similar an adaptation should be met with in such a very different part of the animal kingdom affords considerable indirect support to the interpretation of these *Lycænid* marks and structures, at which so many naturalists have independently arrived. Dr. Haddon kindly permits me to make use of his interesting observation, which has not been hitherto recorded. Mr. G. A. Boulenger, F.R.S., informs me that the fish is *Chartodon plebeius*.

16. EXPERIMENTS ON A CAPTIVE MUNGOOSE (*Herpestes galera*) WITH INSECT-FOOD. (G. A. K. M.)

1899.

May 27. Offered a *Rhopalocampita forestan* to a very young female Mongoose (*Herpestes galera*); she rushed at it, but on touching it with her nose drew back sharply (her eyesight was still but feeble); so I partially cut off its wings and let it flutter on the floor, whereupon she ran at it several times but did not attempt to eat it. I then gave her four *T. senegalensis* (without wings) which she ate greedily, and on being offered a *Mylothris agathina* she promptly seized it, but immediately jumped back so violently that she rolled head over heels. The way she shook her head clearly demonstrated the distastefulness of the butterfly, and she would not let me bring it anywhere near her. I then offered a *Belenois mesentina*, but with the same result; she refused to touch it every time. Thinking this might be due to her experience with the *Mylothris*, I put the *Belenois* aside and offered it ten minutes later, when it was eaten with undoubted relish. An *Acræa caldarena* and *A. axina* were then refused, but without being tasted, the smell being apparently quite sufficient. More than an hour afterwards I again tried her with *B. forestan*, but she would not touch it, though whether this was due to fear of its size and violent fluttering, or to some unpleasant smell, I could not well decide; any way she did not attempt to bite it.

June 3. Gave mongoose two *Terias brigitta*, two *Teracolus omphale*, and two *Belenois severina*. All these had their wings cut off and were thrown on the ground, when they were promptly seized and eaten. A *Mylothris agathina* was then offered in the same manner, and even this was eaten.

- June 4. Mongoose ate three *Terias brigitta*, three *T. senegalensis*, two *Prezis sesamius*, three *Byblia ilithyia*, one *Pyramcis cardui*, and two *Mylothris agathina*.
- „ 7. Mongoose ate three *Acræa avina* and actually one *Limnas chrysippus*. Whether this eating of evidently-unpalatable species is due to the voracious appetite of the animal or to a youthful lack of discrimination it is difficult to say, but probably the former is the truer explanation. I could not observe any marked signs of its having found the insects unpleasant.
- „ 11. Gave mongoose an *Acræa caldarena*, which was promptly eaten. An *L. chrysippus* was then thrown down; she seized it at once, but quickly ejected it with unmistakable signs of distaste. An *A. avina* was treated in a precisely similar manner, so that she seemed to have learned wisdom. Later on she was offered a *Phymateus morbillosus*; she made several attempts to eat it, but its very unpleasant smell deterred her each time.

[These results are interesting and in some respects remarkable. It is probable that some of the apparently-inconsistent results were due to the fact that a voracious insect-eater in extreme youth was gaining its first experience of certain species. Thus the apparent fear of the large Hesperid *Rhopalocampta* was probably, as Mr. Marshall suggests, the inherent timidity of a young animal in the presence of a strange sound and a method of wing-vibration very different from anything which it had witnessed before. The treatment of *Mylothris* suggests that the animal was startled at first by something unusual in taste or smell, but that when it became accustomed to the experience the Pierine was no better defended against the mongoose than against mantides. On the other hand, the behaviour towards *Acræas* and *chrysippus* seems to indicate a progressive recognition of distastefulness or unwholesome qualities. It is unfortunate that the experiments were not greatly extended and prolonged.—E. B. P.]

17. EXPERIMENTS ON A CAPTIVE MUNGOOSE WITH BIRD-FOOD. WARNING CHARACTERS AND DISTASTEFUL QUALITIES IN SOUTH AFRICAN BIRDS. (G. A. K. M.)

[Although this section is strictly speaking outside the scope of the present memoir, it is so closely associated that I have ventured to include it.

Mr. Frank Finn noticed that his mongoose, *Crossarchus fasciatus*, "appeared to be unwilling to attack birds, though it did not seem to find them unpalatable" ("Natural Science," vol. i, No. 10, December 1892, p. 746).—E. B. P.]

Salisbury, Jan. 24, 1900.—I have been recently giving my mongoose some wild birds, and I was much interested to note the result. It ate a dove (*Turtur capicola*), standard wing night-jar (*Cosmetorius vexillarius*), dwarf goose (*Nettapus auritus*), moorhen (*Gallinula chloropus*), and wheatear (*Saxicola pilcata*); while it emphatically refused an owl (*Asio capensis*), kestrel (*Cerchneis rupicoloides*), buff-backed egret (*Herodias lucidus*), hobby (*Falco subbutco*), and drongo (*Buchanga assimilis*). Its dislike of the smell of the common and conspicuous blue-and-black drongo was very marked, especially as it was hungry at the time, and I had plucked the bird clean; it made one or two attempts to eat the meat, but finally gave it up. In the case of this bird and the egret we would therefore seem to have a case of true warning coloration. This is also probably the case with the wood-hoopoes (*Irrisor* and *Rhinopomastus*), which are very conspicuous both in voice and colour—the latter being in both genera black shot with metallic dark-blue or green, with a large white speculum in the wing, and a long tail.

Salisbury, June 26, 1900.—As to distastefulness in birds I must further mention our wood-hoopoes, *Irrisor viridis* and *Rhinopomastus cyanomelas*, both of which emit a strong unpleasant smell. They are both metallic greenish-blue birds with long fan-like tails and a conspicuous white bar on the wings, differing principally in the shape and colouring of the beak. They are also both very noisy, frequently uttering their harsh, chattering cries, and especially when alarmed. Another bird which has well-known distasteful qualities is the ground horn-bill (*Bucorax caffer*). Indeed the Zulus use it on that account for rain-making; they will kill one and throw it into a river, for they say its smell makes the river sick, so that it calls

down the rain to enable it to wash the body away. This bird is black all over with only the primaries white, and is so weak on the wing that after three or four flights a good runner can run it down.

18. EXPERIMENTS ON *Cercopithecus pygerythrus*.
(G. A. K. M.)

The following experiments were all made at one time, in February 1902, at Salisbury. The insects were offered in the following order:—

Psiloptera chalcophoroides: regarded with some suspicion; its head bitten off, and the remainder examined and eaten cautiously.

Amblysterna vittipennis: was offered and eaten at once.

Praogena splendens: was smelt and at once thrown away.

Dichtha inflata: was cautiously smelt and refused.

Amblysterna vittipennis: was regarded with great suspicion, carefully examined and then eaten slowly.

Precis sesamus (*natalensis* form): was received with suspicion and very slowly eaten.

Precis pelagis, *P. sesamus* (*natalensis*), *Byblia acheloia*, and two *Precis antilope* were then eaten readily, but evidently not so much appreciated as the beetles.

Acræa halati was then accepted without suspicion, but when the monkey put it in his mouth, he at once took it out again and looked at it with the utmost surprise for some seconds, and then threw it away. He would have nothing to do with an *A. caldarena* which I then offered him.

[Mr. Marshall was greatly struck with the caution and hesitancy displayed by the monkey, and the evident effect of distasteful forms in causing suspicion of palatable species offered immediately afterwards. I have noticed the same thing with the marmoset ("Colours of Animals," London, 1900, pp. 241, 242).

The refusal of the two Heteromorous Coleoptera, the acceptance of the cryptic species, and the treatment of the Lepidoptera, are in general correspondence with the results obtained in other experiments.—E. B. P.]

19. EXPERIMENTS ON CAPTIVE BABOONS. (G. A. K. M.)

Lepidoptera Rhopalocera.

ACCEPTED.

P. cardui, *R. foresta*, *J. cebreana*, *B. severina*, *C. florella*, *T. achine* (apparently with doubt, the first specimen being rejected at sight but eaten immediately afterwards, others eaten at once).

One *P. corinneus* (taken with suspicion, pulled to pieces and thrown away, then picked up, smelt, and eaten).

A *P. scsanius* ⊕ was pulled to pieces and rejected by the female, but the remains were eaten by the male; each subsequently ate another specimen. *B. ilithyia* refused by female but eaten by male; female ate the second one offered. *C. florella* eaten readily by both. *A. halali* rejected by female at sight, tasted and rejected by male. *L. chrysippus* tasted and rejected by male.

REFUSED.

A. halali, *A. axina* (recognized and refused untasted), *L. chrysippus* (tasted and rejected), *Protoparce convolvuli* (seized eagerly by the female, but on smelling it she regarded it with suspicion; she rubbed it about on the ground and then pulled it to pieces, smelling and rejecting each piece).

Coleoptera.

ACCEPTED.

Polyhirma enigma (with doubt at first); *Peploptera anchoralis*, Jac. (rejected at first and rubbed on the ground, but eaten immediately afterwards); five *Piezia marshalli* (eaten readily); *Polycteis longicornis* and *P. equestris*; *Adoretus flavicollis*; *Graphipterus mashumii*; *Piezia selousi*; *Polyhirma boucardi* and *P. semisuburata*; *Graphipterus tibialis*; *Anomala*, n. sp.; one *Anomalopus plebeius*; *Brachymerus brevicostatus*; *Sternocera funebris*; *Psiloptera chalcophoroides*; *Peploptera zambesiana*; *Micranterus carinatus*.

REFUSED.

Gymnopleurus smaragdinus; *Onitis alexis*; *Epilachna dregei*; *Anthia thoracica* (evidently recognized at once; the baboon seized and flung it on the ground, rubbing it violently, with averted head, as though to kill it); *Clinteria infusata*; *Praogenia festiva*; *Chilomenes lunata*; *Pachnoda flaviventris*; *Onthophagus gazella*; *Mylabris palliata*; *Diacantha conferta*; *Protartia amakosa*; *Zonitis*, sp.; *Plagiodera thoracica*; *Lycus ampliatus*; *L. subtrabeatus*; *L. constrictus*; *L. rostratus*.

A *Mutilla* offered twice but evidently recognized and refused (*Polyhirma enigma* eaten immediately afterwards with scarcely any hesitation). *Eletica rufa* (with evident disgust); *Malacosoma discoidalis*, Jac.; *Prionocerus dimidiatus*; *Decatomia lunata* and *M. tetensis*; *Onitis innuus*; *Oniticellus militaris*; and *Pachnoda rufa* all refused at sight.

Four *Protetia amakosa* and four *Oxythyrea dysenterica* were refused by female at first but eaten rapidly by male. The female eventually ate one of the latter, but evidently in doubt.

The above experiments were conducted at Salisbury in December 1898.

1899.

- Jan. 7. *Psiloptera* are all eaten readily by baboons.
 „ 28. *Byblia ilithyia* eaten by young baboon (*Papio parcarius*). A *Clythra wahlbergi* was offered to baboon, but immediately refused on being smelt (it has a *very* decided *Coccinella*-like odour). The *Coccinellid Epilachna dregci* was refused.
 „ 29. Offered the Longicorn, *Ceroplcis fallax*, to the baboon, which smelt it and shook his head, showing evident alarm when the insect stridulated; on my pulling off the head he took the body and pulled it to pieces, smelling each part, but would not eat it. I then offered him a large brightly-coloured Cetoniid, *Calorrhina loricata*; its strong smell was clearly distasteful to him, so I put the insect on his hand; he was much frightened and tried to shake it off, but could not, owing to its long claws, and was thoroughly terrified by the loud buzzing it made as it finally flew off. Offered *Piezia selousi* to the baboon; I could tell by the way that he tried to snatch sharply at it that he recognized it, and when he did seize it he threw it violently on the ground, rubbing it with his hands (as is their custom with distasteful insects). I picked it up and gave it to him again; he then ate the head, took a bite out of the abdomen and threw the rest away.
 Feb. 1. Another young baboon ate two *B. severina* and two *B. mesentina* with evident relish. It then refused *Onitis alewis* at sight and would not even touch it. An example of *Anomalipus plebeius* was then taken, smelt

and thrown away, although I can detect no smell in this species, which, however, stridulates strongly by rubbing the head against the thorax.

- Feb. 14. Baboon ate one *Colias electra* and one *Byblia ilithyia*. It tasted and rejected first an *A. caldarena*, then an *I. chrysippus*, then rejected at sight several *A. axina* and *A. halali*.
- „ 15. Gave female baboon two *Teracolus achine*, which she ate with appreciation. A *Mylothris agathina* was taken with some doubt, the head and thorax were eaten and a small part of the abdomen, the rest being thrown away; it was clearly not much appreciated. An *I. chrysippus* was tasted and refused. Then an *Acræa anemosa* was offered with under-side exposed to show the bright red and black markings; it was tasted and refused. A *Precis sesamus* ⊕ was then offered in precisely the same manner; the baboon took it, held it in her hand for a few moments and then let it fly away without attempting to smell or taste it. I then cut the wings off another specimen of the same insect, and this was promptly eaten without any signs of distaste. This appears very significant. Then two *Limnas chrysippus* and one *Acræa anemosa* were refused at sight without trial; one *Neptis agatha* was tasted and neglected, and two *Belenois severina* were eaten.
- „ 18. Baboons ate with great avidity two *Anoplocnemis curvipes*, a large strong-smelling Hemipteron all brown in colour. They would have nothing to do with a *Mylabris dicincta* or a *M. tettensis*.
- „ 20. Baboons ate readily four *Brachycerus brevicostatus*, one *Psammodes scabratus*, one *Chlanius cylindricollis*, one *Tragiscoschema wahlbergi*, and also an imago and nymph of the very large and evil-smelling Hemipteron *Petasectis remipes*.

A *Blepisanis haroldi* which was offered to one was taken, immediately thrown down without even being smelt; on re-presentation it was smelt and tasted cautiously, found to be palatable, and eaten; there can be little doubt that it was mistaken for one of the synaposematic members of the powerful Lycoid group. A larva of *Præcis sesamius* was neglected by both baboons, neither taking the slightest interest in it.

- Feb. 24. Baboons ate greedily two *Anoplocnemis curvipes*. As I was taking an *Anthia massilicata* out of a box the male baboon made a snap at it and received a good dose of its powerful acid in his mouth, which made him start back in a great fright, making most comical grimaces; I then offered the beetle piecemeal to the other baboon, and it was eaten with relish except the anal portion of the abdomen, which was rejected. This is of interest in connection with the immediate recognition and violent rejection of *A. thoracica* by the female in an earlier experiment. One *Catopsilia florella* and three *Terias brigitta* were next eaten. Then two *Byblia ilithyia* were offered with the upper-side exposed, and were eaten with undoubted appreciation by the female; I then showed her a large brightly-coloured example of *Acræa rakira*, also exposing the upper-side, but she recognized it, merely taking it, pulling its head off and throwing it on the ground without even smelling it. She then ate two more *B. ilithyia*, and finally I offered her an *ilithyia* and an *Acræa axina* together, both having their wings closed and being held close to one another; she took and ate the former, but quite neglected the latter. This experiment tends to show that the general resemblance which *Byblia* bears to an

Acræa is not sufficiently close to deceive a baboon.

Feb. 25. Gave baboon a *B. ilithyia*, which was eaten without hesitation, then an *Acræa halali*, which she rubbed in her hands as though preparatory to eating, but eventually threw down without even smelling it; she then ate another *B. ilithyia*.

March 20. Gave baboons three specimens of a brightly-coloured black-and-yellow spider (*Gasteracantha ornata*). They viewed them with some distrust at first, but eventually ate them with appreciation.

„ 22. Baboons ate one *Precis archesia* and two male *Hypolimnas misippus*, but rejected a *Mylothris agathina*. They further ate two *B. ilithyia*, three *Atella phalantha*, and one *Precis sesamus* ⊕. I then offered an *Acræa natalica*, which was seized, smelt, and thrown away; another *P. sesamus* ⊙ was offered immediately afterwards and neglected.

„ 26. Gave baboon a *Mylothris agathina*; she regarded it with some suspicion, but eventually ate it very slowly and evidently did not care about it. I then gave her another specimen; she pulled the abdomen off, smelt at the exuding juices, and after tasting them gingerly with her tongue, threw the insect away. After this two *Belenois severina* were eaten with relish. I then gave her a *Neptis agatha*, and she seemed to hesitate about taking it, and after tasting a portion of the abdomen neglected it. Of a second specimen she ate rather more before throwing it down; the remains I offered to the other baboon; he tasted it and seemed in doubt for some time as to whether it was fit to eat or not, but finally rejected it.

April 9. Gave baboon a female *Hypolimnas misippus*, var. *inaria*, of which I had cut off the

- wings; she ate it readily and likewise a *P. sesamius*.
- April 22. The female baboon ate with relish a male *Hypolimnas misippus* and a *Prezis sesamius* ☉. I then gave her a *B. ilithyia*, which she pulled to pieces and threw down, but then changed her mind, picked up the thorax and ate it, and immediately afterwards she ate three more examples in quick succession without hesitation. A single *B. ilithyia* given to the male was pulled to pieces and neglected.
- „ 23. A *Rhopalocampa forestan* and *R. pisistratas* were eaten with avidity by female baboon; she watched with great eagerness while I opened another box, and was evidently disappointed when I produced a *Belenois mesentina*; she ate it, however, and another after it. She seemed doubtful about a *Herpænia eriphia*, but while she was tasting it the male made a grab at it, and I could not decide whether the insect was really appreciated.
- May 1. The female baboon ate a *Papilio corinnus* without any signs of distaste, and likewise a *Belenois mesentina*. She then took a *H. eriphia*, but without eagerness, and pulled it to pieces, tasting it gingerly, and finally rejected three-parts of it. Another *B. mesentina* was then offered and neglected.
- „ 21. Offered female baboon a larva of *B. mesentina*. She was clearly afraid of it, snatching it from my hand and throwing it down, but she soon picked it up again and began examining it very cautiously; finally she decided to taste it, and after some consideration came to the conclusion that it was all right. She then eagerly devoured over twenty of them, though it was evident she did not like to feel them wriggling in her hand. I noticed that she almost always squeezed out the excreta of the caterpillars before eating

them. The male was much too frightened to eat them in spite of the example of the female. I then gave a *B. severina* to the female and a *B. mesentina* to the male, both being eaten readily. The female made a grab at my box, seized a *Mylothris agathina* and a *B. mesentina* together and began eating them at the same time; she soon found something was wrong and dropped them, then picked up the *Mylothris*, tasted it and threw it away, eating the *Belenois* afterwards. The male, who had meantime eaten another *B. mesentina*, picked up the discarded *Mylothris*, but on tasting it also at once rejected it. Then four *Tera-colus omphale* and three *T. achine* were eaten with undoubted appreciation by both baboons. On giving each a *H. eriphia* they were both tasted and rejected; the female ate a *T. phlegyas* and neglected another *H. eriphia*.

There can be little doubt as to the distastefulness of this latter insect to a certain extent, but I should be inclined to rank it rather lower than *Mylothris* and about on a par with *Neptis agatha*.

Finally, six *Terias senegalensis* were eaten without any sign of distaste by both baboons, though the insects are too small to be much appreciated by them.

Salisbury, Sept. 21, 1900.—I could not yet say what protective character is possessed by the *Ichnumonidæ*, but with the Bracons there can be no doubt that it consists in their having a very strong and unpleasant smell, somewhat resembling that of the *Coccinellidæ*, only rather more pungent. They do not attempt to defend themselves by stinging, and their flight is slow, rendering them very conspicuous on the wing. I gave one of the common red species to my monkey (*Cercoptes pygerythrus*) the other day. He put it straight into his mouth without smelling it, but soon spat it out again. I then offered the mangled remains to one of the baboons, but she merely smelt and rejected them. It is interesting to note that

the baboons, which eat insects largely, are much more cautious in receiving any food than is the *Cercopithecus*.

20. CONCLUSIONS FROM EXPERIMENTS ON CAPTIVE BABOONS, MUNGOOSE, AND KESTRELS. (G. A. K. M.)

[Mr. Marshall's notes on these insectivorous animals were in one series, which I have analyzed for the purpose of this memoir. Hence the following references in his letters deal with the experiments as a whole, except in those instances in which a particular animal is named.—E. B. P.]

Salisbury, June 20, 1899.—In view of the above experiments it seems to me impossible to regard such genera as *Terias*, *Teracolus*, *Belenois*, *Byblia*, etc. as unpalatable. I quite agree with your excellent suggestion that distasteful characters probably first arose in the larval stage and were transmitted to the imago, and this view lends further support to the presumed palatability of *Belenois*, for my baboon ate the larvæ with much relish. *Teracolus* likewise I must still regard as a non-distasteful genus, at least so far as the orange- and purple-tipped groups are concerned.

I was much pleased with the undoubted proof of mimicry [in the experiments with baboons] in the case of *Precis sesamus* \oplus , for I do not recollect having seen an account of direct experimental proof before.

With *Byblia* I was not so successful as I had hoped, but I am inclined to attribute the hesitation in accepting this species, which was observed in some instances, to imperfect mimicry. I fully recognize the difficulty in distinguishing in such experiments between Batesian and slightly Müllerian mimics, as either might be received with hesitation at first, though if subsequent specimens were eaten readily (as in the case of *Byblia*) I should think they must be included in the former category.

The eager acceptance of the malodorous Coreid bugs by my baboons came as a very great surprise to me, and several other results in these experiments point to the great danger of generalizing on the unpalatability or otherwise of insects, from the results of experiments on only one kind of animal.

Salisbury, April 25, 1899.—I may mention that so far as my experiments go I have no evidence for the unpalatability of *Terias*, *Teracolus*, *Belenois*, *Byblia*, *Precis*, or *Hypolimnas*, whereas *Mylothris* and *Neptis* are certainly distasteful to some extent.

21. CONCLUSIONS FROM EXPERIMENTS ON BABOONS. (E. B. P.)

Some of the most interesting results were those which show the actual working of the principle on which the theory of mimicry depends; especially the twice-repeated experiment with the exposed under-side of the distasteful *Acræa anemosa*, resulting in the escape of the *Precis sesamius* \oplus with a somewhat similar under-side, while the same species deprived of its wings was readily eaten. At the same time a *P. sesamius* \oplus was on one occasion rejected by the female without any preparatory display of an *Acræa*. The suspicion of the Lycoid Longicorn, *Blepisanis haroldi*, dispelled when it was tasted, points in the same direction. On the other hand, the baboons were not imposed upon by the resemblance of the Carabid *Polyhirma enigma* to a *Mutilla*. In the natural state the swiftly-running Carabid would have a much better chance of this pseudaposematic protection than under the conditions of an experiment with captive insect-eaters. *Byblia ilithyia* was similarly distinguished from an *Acræa*; but this by no means proves that the resemblance is not beneficial under natural conditions.

As regards Lepidoptera, the refusal of a *Protoparce convolvuli*, after examination of every fragment of it, is most remarkable. The insect at rest is apparently a beautiful example of cryptic colouring. Further experiments are very desirable.

The *Acræinæ* (*avina*, *caldarena*, *rahira*, *anemosa*, *halali*) and *L. chrysippus* were never eaten, although sometimes tasted; on many occasions they were recognized at sight, and refused. *Mylothris agathina* was sometimes partly and once completely eaten, but it was usually rejected and evidently unpalatable to them. *Neptis agatha* was also generally tasted and neglected, and never entirely eaten. The Pierine *Herpænia eriphia* was also evidently distasteful. Other butterflies which were usually eaten did not appear to be a food which is much appreciated. Thus *B. ilithyia* was sometimes neglected and sometimes only partially eaten; *Teracolus achine* was on one occasion eaten "with doubt," and the same was true of one *Papilio corinæus*. The two large Hesperids of the genus *Rhopalocampta* were, on the other hand, eaten with relish, and the baboon showed evident disappointment on receiving *Belenois*

mesentina after them. Apart from these examples of hesitation, disappointment, and refusal in part or complete, the baboons ate many species of *Pierinæ* (*Teracolus*, *Colias*, *Terias*, *Belenois*, *Catopsilia*) and *Nymphaliniæ* (*Junonia*, *Precis*, *Pyrameis*, *Atella*, *Hypolimnas*), but refused to touch the larva of *Precis sesamus*. Considering what has been already argued about insect-eating animals in confinement, the acceptances (excluding the *Hesperidæ*) probably do not justify the conclusion that the Lepidoptera were palatable, or that they would be sought for in the wild state except under the stress of hunger. The treatment of the larva of *Belenois mesentina* certainly seems to indicate palatability to the baboon, and also that it was a first experience of this caterpillar.

The experiments with Hymenoptera are particularly valuable; for although *Mutillidæ* and *Braconidæ* are so greatly mimicked, there is practically no direct evidence that they are refused by insect-eaters.

The fact that the two large species of Hemiptera were eaten, in one case "with great avidity," is a further example of the failure of a mode of defence which produces a great impression upon man, viz. the emission of an odour offensive to us. The suspicion created by the conspicuous spiders was probably due to unpleasant experiences of insects with a similar combination of colours.

The numerous experiments with Coleoptera are exceptionally interesting. I have below tabulated the results under A, acceptances, and B, rejections. It is seen that the species of the following groups were refused without any exceptions:—*Lycidæ*, *Melyridæ*, *Cantharidæ*, *Coccinellidæ*, and *Scarabeidæ*, while those belonging to the *Rutelidæ*, *Buprestidæ*, and *Curculionidæ* were invariably accepted. The uniform refusal of five species of Scarabeids is somewhat surprising, but all of them possessed iridescent colours. Of the six *Cetoniidæ* offered, four were always refused, two being sometimes rejected and sometimes eaten. The only Phytophaga eaten were two *Clythridæ* of the genus *Peploptera*, and one of these was refused at first. The cryptic Heteromera were accepted, although one of them was smelt and refused on one occasion; the iridescent species was rejected. Longicornia were eaten, except the Cantharid-like *Ceroplesis*, which is probably synaposematic (compare p. 396). The *Carabidæ* were extremely interesting. The acid secretion appears to be their

undoubted defence against baboons as it was against the kestrels (pp. 342-3). Hence the small and medium-sized species were eaten somewhat freely, although with evidence from time to time that the acid was disliked, and, on the other hand, a large species with a greater amount of secretion was avoided, and evidently recognized at sight. Another one being seized, discharged its secretion into the baboon's mouth with immense effect. When however it was killed and offered piecemeal, all the parts except those which contained the acid were eaten by the other baboon. If we allow for the fact that *Carabidæ*, attacked under natural conditions, have a much larger supply of the acid, we must admit that they possess a very powerful defence, and that the meaning of the chief quality which underlies the aposematic appearance of the large species is tolerably clear.

A.—*Colcoptera accepted by Baboons.*

GROUP.	SPECIES.	SIZE AND APPEARANCE.
CARABIDÆ.	<i>Piezia marshalli</i> .	Medium; black with white lines and patches.
	„ <i>selousi</i> (sometimes treated as if distasteful and only partly eaten).	Largish; similar coloration to above.
	<i>Polyhirma anigma</i> (with doubt at first).	Smallish; black, white-spotted.
	<i>Polyhirma boucardi</i> .	Largish; black with white dorsal thoracic line.
	<i>Polyhirma semisuturala</i> .	Medium; black with white lines and patches.
	<i>Graphipterus nashunus</i> .	Smallish; black with tawny lines and spots.
	<i>Graphipterus tibialis</i> .	Small; grey-brown, with grey linear markings.
	<i>Chlæniuscylindricollis</i> .	Medium; green, with yellow margin to elytra and yellow legs.
RUTELIDÆ.	<i>Anomala</i> , sp. nov.	Medium; testaceous.
	<i>Adoretus flavcolus</i> .	Smallish; „
BUPRESTIDÆ.	All <i>Psiloptera</i> (including the largish <i>P. chalcophoroides</i>).	Cryptic colouring.
	<i>Sternocera funebris</i> .	Large; shiny black, with white hairs on thorax.
CURCULIONIDÆ.	<i>Brachycerus brevicostatus</i> .	Large; cryptic.
	<i>Polycleis longicornis</i> .	Largish; black, with yellow spots on elytra.
	„ <i>equestris</i> , var.	Largish; iridescent blue-green with red oblique band on elytra.

GROUP.	SPECIES.	SIZE AND APPEARANCE.
HETEROMERA.	<i>Psammodes scabratus.</i>	Large; cryptic.
	<i>Anomalipus plebeius</i> (once refused after smelling).	Large; black, often earthy, and probably allocryptic.
	<i>Micrantercus carinatus.</i>	Medium; probably earthy and allocryptic female, shining black male.
PHYTOPHAGA.	<i>Peploptera anchoralis</i> (rejected at first).	Medium; yellow with black spots and bands (<i>Clythridæ</i>).
LONGICORNIA.	<i>Peploptera zambesiana.</i>	Similar to above.
	<i>Tragischoschema wahl- bergi.</i>	Smallish; black with con- spicuous orange markings.
	<i>Blepisanis haroldi.</i>	Small; Lycoid.

B.—Coleoptera rejected by Baboons.

GROUP.	SPECIES.	SIZE AND APPEARANCE.
LYCIDÆ.	Four species.	Warning coloration charac- teristic of African <i>Lycidæ</i> .
MELYRIDÆ.	<i>Prionocerus dimidiatus.</i>	Lycoid coloration.
CANTHARIDÆ.	<i>Zonitis</i> sp.	Characteristic Cantharid and Lycoid (e. g. <i>M. palliata</i> , etc.) coloration, orange and black.
	<i>Eletica rufa.</i>	
	<i>Decatomia lunata.</i>	
	„ <i>tettensis.</i>	
	„ <i>dicincta.</i>	
COCCINELLIDÆ.	„ <i>palliata.</i>	
	<i>Chilomenes lunata.</i>	Characteristic Coccinellid col- oration.
	<i>Epilachna dregei.</i>	
PHYTOPHAGA.	<i>Malacosoma discoida- lis.</i>	Medium; nearly black with narrow yellow band at apex, and at base of elytra.
	<i>Diacantha conferta.</i>	Lycoid coloration.
	<i>Plagiodera thoracica.</i>	Largish; red-brown thorax, iridescent blue or green elytra.
	<i>Clythra wahlbergi.</i>	Medium; Cantharid type, orange and black.
	<i>Clinteria infuscata.</i>	Medium; brown elytra, some- times black, orange thorax with two black spots.
CETONIIDÆ.	<i>Pachnoda flaviventris.</i>	Large; greenish-black with orange markings.
	„ <i>rufa.</i>	Large; thorax green, greenish- orange elytra.
	<i>Protaxia amakosa</i> (sometimes eaten).	Smallish; black with many small white spots.
	<i>Oxythyrea dysenterica</i> (sometimes eaten).	Smallish; shining green or blue elytra and red thorax.
	<i>Coelorrhina loricata.</i>	Largish; green thorax and scutellum, yellow elytra with 4 black spots; brick- red head and legs.
	<i>Onitis innuus.</i>	Largish; iridescent dark- green.
SCARABÆIDÆ.		

GROUP.	SPECIES.	SIZE AND APPEARANCE.
SCARABÆIDÆ.	<i>Onitis alexis</i> .	Medium; brown elytra and legs, iridescent green thorax and head.
	<i>Onthophagus gazella</i> .	Smallish; similar colouring to above.
	<i>Gymnopleurus smaragdinus</i> .	Small; iridescent green, blue, or red.
	<i>Oniticellus militaris</i> .	Small; probably when fresh iridescent dark-green with orange markings.
HETEROMERA.	<i>Praogena festiva</i> .	Medium; almost black with purplish iridescent reflections on elytra, bluish on thorax.
CARABIDÆ.	<i>Anthia thoracica</i> .	Large; black, white spot on thorax and white margin to elytra. Huge mandibles.
	„ <i>massilicata</i> (only eaten when offered piecemeal).	Large; black with pale margin to elytra. Huge mandibles.
LONGICORNIA.	<i>Ceropopsis fallax</i> .	Large; black, yellow-banded, Cantharid type.

22. THE CHIEF CONSPICUOUS SPECIALLY-DEFENDED GROUPS IN THE COLEOPTERA INFERRED FROM G. A. K. MARSHALL'S EXPERIMENTS. A COMPARISON BETWEEN COLEOPTERA AND LEPIDOPTERA IN THIS RESPECT. (E. B. P.)

It is of great interest to attempt to conclude from the results of the experiments on the palatability of conspicuous Coleoptera contained in this memoir, and from previously recorded observations and experiments on the same order of insects, what are the chief specially defended groups which may be considered to stand in the same position towards their allies as the *Ithomiinæ*, *Danainæ*, *Heliconiæ* and *Acræinæ* do to the rest of the Rhopalocera, and the *Agaristidæ*, *Syntomidæ*, *Zygænidæ*, etc., do to the rest of the Heterocera.

The chief memoirs upon which the conclusions stated below have been based are published in the Transactions of the Entomological Society of London. They are the papers by Mr. C. J. Gahan (1891, p. 367), by Mr. H. Donisthorpe (1901, p. 345), and the Presidential Address of Canon W. W. Fowler, Jan. 15, 1902 (Proc. 1901, p. xxxiii). I have also had the opportunity of reading the manuscript of an important paper by Mr. R. Shelford on mimicry in Bornean insects, now being published by the Zoological

Society of London, and of arranging an abstract which is printed in the Report of the British Association at Bradford, 1900, p. 795.

But, above all, I wish to express my thanks to Mr. C. J. Gahan and Mr. G. A. K. Marshall for their kind advice and assistance in the attempt to arrive at sound conclusions.

The groups about which there seems to be no doubt at all—conspicuous, constantly refused by insect-eaters, and liable to be mimicked by other Coleoptera—are the following:—

1. EROTYLIDÆ. Very apt to enter into conspicuous combinations which are doubtless synaposematic with other beetles.

2. COCCINELLIDÆ. Greatly mimicked by other beetles and insects of other orders. Very commonly form synaposematic assemblages (see p. 520).

3. MALACODERMIDÆ, including the *Lycinæ*, *Lampyrinæ*, and *Telephorinæ*. Greatly mimicked by beetles of other families, and also by insects of other Orders (see pp. 515–518).

4. MELYRIDÆ. Some of the species convergent towards *Lycinæ* and *Telephorinæ*; others characterized by the possession of thoracic glands, which are exserted when the insect is irritated.

5. CANTHARIDÆ. Undoubtedly a distasteful group with conspicuous warning coloration. Some of the species are synaposematic with other beetles, and with Aculeate Hymenoptera (see pp. 516–518 and 525–527), while others afford models for mimicry and synaposematic approach (pp. 518, 519).

6. CHRYSOMELIDÆ. The sub-families, *Galerucinæ* and *Hispinæ* are especially largely mimicked by other beetles, and fall into synaposematic combinations. The *Chrysomelinæ*, *Eumolpinæ*, etc., also enter into combinations which are doubtless Müllerian (synaposematic). The *Megalopinæ*, however, may be mimetic (pseudaposematic) rather than synaposematic.

Concerning the last-named family, Mr. Gahan writes to me, March 3, 1902:—

“In reference to my previous paper on *Diabrotica* [Trans. Ent. Soc. Lond., 1891, p. 367], there are a few facts since published in a paper by F. M. Webster ‘On the probable origin, development, and diffusion of North American species of *Diabrotica*.’

“ ‘The fact that several species of this genus are literally swarming over large areas of country, and their habits are such as to expose them almost continually during the adult stage to attacks of birds, while in all of the investigations of the food of birds they rarely appear, has raised the question of their being inedible.’

“ Webster gives also a quotation from Bates’ ‘Naturalist on River Amazon,’ which I had overlooked:—

“ ‘The Eumolpidæ and Galerucidæ were much more numerous than the Chlamydes and Lamprosomas, although being also leaf-eaters, and having neither the disguised appearance of the one nor the hard integuments of the other; but many of them secrete a foul liquor when handled, which may perhaps serve the same purpose of passive defence.’ ”

There are two other groups which may eventually be placed beside the six families named above.

ENDOMYCHIDÆ. Mr. Shelford’s experiments show that several of the Bornean species are most distasteful. They are abundant and extremely conspicuous; they form synaposematic groups, especially with the *Erotylidæ*, and there is one beautiful example of mimetic resemblance to an Endomychid model by a Bornean Longicorn. The style of colouring in the family suggests that it contains Müllerian groups (see also p. 522).

PYROCHROIDÆ. The colouring and habits suggest that these Coleoptera are highly distasteful; they may even belong to the first rank in this respect.

We now pass to a Coleopterous family which may with more probability be placed beside the *Hypsidæ* or *Chalcosinæ*, undoubtedly distasteful groups of moths which nevertheless are exceedingly apt to display Müllerian resemblances to other presumably still more strongly-protected Lepidoptera. In such synaposematic combinations they appear perhaps invariably to take the patterns and colours of others, rather than impress the stamp of their own likeness on the assemblage.

CLERIDÆ. These beetles are, like the above-named moths, most apt to take on the appearance of still more distasteful allies, such as the *Lycinæ*, the *Cantharidæ*, the *Galerucinæ*, and, in the genus *Allochotes*, the *Coccinellidæ*. They are great mimics of *Mutillidæ*, and less commonly of ants. Mr. Shelford has come across one beautiful example of the mimicry of common Bornean Clerids of the genus

Lemidia, by a Longicorn of the genus *Daphisia*. The common mimicry of *Mutillidae* may be due to an original body-form, size, and colouring, which rendered the resemblance to such models peculiarly easy and rapid of attainment by selective means. *Cleridae* also occasionally possess warning colours of their own. Examples are found in the genus *Lemidia* mentioned above, and in an abundant, bright-red, strongly-smelling South African species of a genus which is probably new. The latter was rejected by insect-eating animals (see p. 344).

We now come to four groups which the experiments here recorded show to be at any rate partially distasteful. They are often very conspicuous, sometimes from an aposematic colouring peculiar to themselves, sometimes from their sluggish movements and size, and the manner in which they expose themselves or move freely in the open. They are, however, not as a rule mimicked by other beetles, and they do not largely enter into synaposematic association with the most distasteful Coleoptera.

SCARABÆIDÆ. The diurnal South African species are all conspicuous, and freely expose themselves. Their colours, black, green, or coppery, are all conspicuous against the ground on which they are always found. The largest South African species (*Scarabæus femoralis*) adopts a warning attitude when it is disturbed. Many of the species were evidently distasteful to insect-eaters. It is possible that their special defence is due to the nature of their food.

CETONIIDÆ. The majority of South African species, including all the larger species, are conspicuous on flowers or exuding gum. They freely take wing in sunshine, but are quite sluggish in cloudy weather. Their colours vary greatly, but very conspicuous and contrasted tints are often present. Many of the species were found to be unpalatable.

TENEBRIONIDÆ. Mostly dull browns and blacks, generally diurnal, terrestrial, and slow-moving. Several species proved to be distasteful.

LAGRIIDÆ. The South African species are often iridescent green or purplish, many brown or black. They are abundant and very sluggish; they freely expose themselves in conspicuous positions on leaves, and have a strong smell. Although but few experiments were made, it is probable that the whole group is distasteful.

The case of the Longicornia is peculiarly interesting.

They may be considered as parallel to the *Nymphalinae* among Rhopalocera. In both we have a great preponderance of species with cryptic habits and colouring, while genera mimetic of the most distasteful groups of their respective Orders are also common. In some of these examples the mimicry is almost certainly Müllerian, as in the case of *Neptis* and *Limenitis* among the *Nymphalinae* and *Cymatura* and *Ceropalesis* among Longicorns. Furthermore, the *Clytinae* and *Callichrominae* have been shown by Mr. Shelford to be mimicked in Borneo on a large scale by other Longicorns, although the former tend strongly to mimic Aculeates in nearly all parts of the world. Similarly, there is good reason for thinking that the genera *Neptis* and *Limenitis*, which may be mimetic, are also themselves mimicked by other *Nymphalinae*, etc.

There remain the remarkable cases of the *Cicindelidae*, *Carabidae*, and *Curculionidae*, which are probably without any strict analogy in the Lepidoptera. The two former require special mention, the last-named are treated separately on pp. 522-525.

CICINDELIDÆ. These Coleoptera supply models for mimicry by a Locustid in Borneo, and Mr. Shelford also considers that one of them is mimicked by a fly. They are also known to be mimicked by Longicorns. Many South African *Cicindelidae* are convergent towards, or mimetic of, *Carabidae*, especially those of the latter which are themselves convergent towards *Mutillidae* (see pp. 511-515). Some of the species have a peculiar scent. On the other hand, their swift movements and retiring habits are inconsistent with a high form of special protection.

CARABIDÆ. Mimicked in Borneo by a Locustid. Probably more strongly defended by the possession of anal glands than are the *Cicindelidae*, and in the combinations between the two families it is seen that the latter have approached the former, rather than *vice versâ*. Certain groups of *Carabidae* form pseud- or synaposematic combinations with the *Galerucinae* and also with the *Mutillidae*. The South African smaller and moderate-sized diurnal species have habits very similar to the *Cicindelidae*, but are not so swift. They commonly possess directive marks indicating the specially-protected anal region. The largest South African species (*Anthia*) have a very large charge of the defensive secretion and extremely powerful mandibles. They freely expose them-

selves, and are most conspicuous, often possessing a highly-characteristic warning pattern. They adopt special warning attitudes, and do not run away when they are attacked (see p. 510).

These two families may be perhaps compared to the powerful group of the hawks, which are mimicked by the feeble cuckoos, and yet, when attacked, are themselves swift in flight, but can render a good account of themselves when active defence becomes necessary.

23. EXPERIMENTAL EVIDENCE OF THE VALUE OF THE
TERRIFYING MARKINGS IN *Chærocampa* LARVÆ.
(G. A. K. M.)

Salisbury, April 16, 1899.—I offered baboons a full-grown larva (about seven inches long) of *Chærocampa osiris*. The larva is remarkably snake-like, the general colouring somewhat recalling that of the common puff-adder (*Bitis arietans*). The female baboon ran forward expecting a tit-bit, but when she saw what I had brought she flicked it out of my hand on to the ground, at the same time jumping back suspiciously; she then approached it very cautiously, and after peering carefully at it from the distance of about a foot, she withdrew in alarm, being clearly much impressed by the large blue eye-like markings. The male baboon, which has a much more nervous temperament, had meanwhile remained at a distance surveying the proceedings, so I picked up the caterpillar and brought it towards them, but they would not let me approach, and kept running away round and round their pole, so I threw the insect at them. Their fright was ludicrous to see; with loud cries they jumped aside and clambered up the pole as fast as they could go, into their box, where they sat peering over the edge watching the uncanny object below. After a while the female seemed inclined to descend to investigate matters again, but owing to the manner in which they had entangled their ropes she could not descend without the male, and he very emphatically refused to move. On concealing the larva I managed to coax them down again, and then seizing the rope to which the male was tied, I drew him slowly towards me holding up the larva in the other hand; he simply screamed in abject terror, so I let him go, and they retired to their box. The whole performance was a most remarkable demonstration of the high value of the terrifying colours in these larvæ.

. . . Their terror of the insect was most amusing, and was an eloquent testimony to the great value of this form of colouring to so bulky a larva. I do not think any one could now argue that the theory of terrifying coloration is far-fetched, as I have heard contended. The snake-like appearance seems capable of deceiving more intelligent animals than baboons, for it is not long since I received a box containing a mutilated specimen of this caterpillar accompanied by a note inquiring, "Is this a snake?"

[This evidence recently obtained by Mr. Marshall, added to that already published by Professor Weismann, Lady Verney, and the present writer ("Colours of Animals," London, 1890, pp. 260, 261), leaves no doubt that the conspicuous eye-spots of *Charocampa* and other large larvæ are really terrifying and do actually alarm their enemies. The results observed are consistent with the production of a feeling of terror rather than of distaste or repugnance such as Portschinski supposes to result from the sight of an ocellated spot. In his remarkable papers on "Coloration marquante et Taches ocellées" (St. Petersburg), this acute and imaginative naturalist states his belief that ocellated spots represent the appearance of a drop of warning liquid. He develops this hypothesis with the greatest ingenuity, and describes and illustrates a large number of such spots in insects of many kinds. In some ocellated spots he sees represented the reflection of the sky in a drop of warning liquid; in others, the distorting effect of gravity upon a drop resting on a vertical surface: in the sounds made by certain irritated Mantides, as they display the spots on their raptorial legs, he believes he hears a representation of the rushing sound of a warning liquid forced through a fine aperture. My kind friend Professor W. R. Morfill has given me the opportunity of learning the remarkable and highly-imaginative views of the distinguished Russian naturalist. On some future occasion I hope to be able to lay them before English-speaking naturalists in much greater detail. For the present I desire to point out that the results obtained by experiment do not support his conclusions, but suggest in the most convincing manner that terror, such as is caused by the appearance of a serpent, is produced by the display of eye-like marks on a large caterpillar. Terror may be similarly caused by the display of large ocellated spots on the wings of imagines, while in other

cases they probably act as directive marks, diverting the attention of an enemy from the body of the insect (see pp. 371-5 and 440-1). To the former category probably belong the remarkable eye-like spots on the tegmina of certain Harpagid Mantides; for Mr. Marshall writes (1902) of a South African species: "The eye-like markings on the wings of the Mantis, *Pseudocreobotra wahlbergi*, are, I think, almost certainly of a terrifying character. When the insect is irritated the wings are raised over its back in such a manner that the tegmina stand side by side, and the markings on them then present a very striking resemblance to the great yellow eyes of a bird of prey, or some feline animal, which might well deter an insectivorous enemy. It is noticeable that the insect is always careful to keep the wings directed towards the point of attack, and this is often done without altering the position of the body."—E. B. P.]

24. EVIDENCE OF A SUPERSTITIOUS DREAD OF THE LARVA OF *Charocampa elpenor*. (E. B. P.)

Professor Weismann and Lady Verney have shown that the larva of *C. elpenor* terrifies birds, and I have found that *Lacerta viridis* was at first much intimidated, but finally overcame its fright and devoured the larva. An account of these observations is given in "Colours of Animals," Poulton, 1890, pp. 260, 261. I have recently ascertained that the larva is regarded with superstitious fear in certain parts of Ireland. This I owe to the kindness of my friend Mrs. Nuttall, the American anthropologist, who has drawn my attention to an article by Mrs. Frances J. Battersby, of Cromlyn, Westmeath, in "Knowledge," vol. 21, 1898, p. 256, and reprinted in "Public Opinion," Nov. 11, 1898, p. 622. The writer quotes the following quaint and amusing account of the larva, and the sympathetic magic by which its supposed evil influence is cured, from "A Chorographical Description of the County Westmeath," by Sir Henry Piers, of Insternaght (1682): "We have a certain reptile found in our bogs called by the Irish the 'Connagh worm.' This is an ugly worm, sometimes as thick as a man's thumb, about two or three inches long, having, as all reptiles have, many short feet, a large head, great goggle eyes and glaring, between which riseth or jutteth forth one thick bristle, in shape like a horn, which

is prominent and bendeth forward about three-quarters of an inch. Whatever beast happeneth to feed where this venomous worm hath crept (some say if he do but tread there) is certainly poisoned, yet may be infallibly cured if timely remedy be applied; the case is twofold, yet in effect but one, both proceeding from the very worm itself. Some there are that take this worm and, putting it into the hand of a new-born child, close the hand about it, tying it up with the worm closed in it till it be dead. This child ever after, by stroking the beast affected recovers it, and so it will if the water wherein the child washes be sprinkled on the beast. I have known a man that thus would cure his neighbours' cattle though he never saw them. The other method of cure, which I like much better, is by boring an augur-hole in a well-grown willow-tree, and in it imprisoning but not immediately killing the worm, so close by a wooden peg that no air may get in, and therein leaving him to die at leisure. The leaves and tender branches of this tree ever after if bruised in water, and the affected beast therewith be sprinkled, he is cured. The All-wise and Ever-gracious God having thus in His Providence ordered it that not only this venomous reptile, but divers others, and who knows if not all, did we know the right method of using them, should have in themselves their own antidotes, that so we might have a remedy at hand as the poet sayeth:—

‘*Una eademque manus vulnus opemque ferat.*’”

The authoress also shows that a superstitious dread of the larva still persists among the Irish folk. In all the descriptions the terrifying eye-like marks have a prominent place. A “clergyman’s daughter, walking near a ditch, ‘saw her little dog barking and snapping at a most curious-looking creature with staring goggle eyes.’” One of the country-folk said that the creature “had a round head like a cat’s, and goggle eyes.” “He was afraid to touch it, as its eyes glared like a frog’s, and said it bit or stung cattle, when their heads swelled up; and a man was once bit on the leg, which swelled up, and he nearly died.” A labourer, going to fetch a tin basin from a field, “found a Connagh sitting in it, glaring at him.” A woman lost one of these caterpillars which she was carrying on a stick, and was reproved by her father “for not having killed the Connagh by smashing it with a stone, ‘as now it would sting the cattle.’” The authoress, who is an experienced collector

of Lepidoptera, has also shown specimens of the larva to the country-folk, and ascertained that it was what they call the "Connagh," so that we are not dependent for the identification upon the loose descriptions of ignorant and excited people. She states that there are two models of the "Connagh" in the Dublin Museum "studded with coloured stones, and supposed to have been used as charms." *

Miss Eleanor A. Ormerod in her Eleventh Report, for 1887 (p. 126), also shows that this larva is looked upon "at least in one district in Ireland as the cause of murrain in cattle." Thus "In the course of last year Miss Fleming, writing from Derry Lea, Monasterevan, Co. Kildare, Ireland, mentioned:—'There is a very large caterpillar sometimes found here (I have seen it four inches long), which is said by popular voice to give the disease called "murrain" when licked or swallowed by a cow. The people call this creeping thing a Murrain Worm.'" On Aug. 7, 1887, Miss Fleming sent a specimen which proved to be the larva of *C. elpenor*. Another specimen was sent on Aug. 20, 1887, to Miss Ormerod, by Mr. N. Richardson, from the Estate Office, Castle Comer, Co. Kilkenny.

In the autumn of 1898 (Twenty-second Report, for 1898, p. 72) Miss Ormerod received from Mr. Thomas Wade, of Newcastle-West, Co. Limerick, an account of the disease of a cow which "the farmers, not only here, but all over Munster, seem convinced . . . is caused by 'a worm.'" Although Mr. Wade suggests that they refer to "a lizard, or something akin to it," it is almost certain that we have here another case of the same superstition.

Mr. G. H. Carpenter, B.Sc., F.E.S., of the Science and Art Museum, Dublin, informs me that in 1901 a police-constable in Co. Mayo forwarded a larva of *elpenor* as "a rare kind of reptile," and that a similar description has been given to him by other country correspondents. The evidence of alarm and superstitious dread is however of greater significance than the employment of a word which is so often used inaccurately.

* Mr. Carpenter informs me that the cylindrical form of these models and the large size of the caudal horn on one of them suggest *Acherontia* rather than *Cherocampa*.

25. EXPERIMENTAL EVIDENCE OF TERROR CAUSED BY THE SQUEAK OF *Acherontia atropos*. (G. A. K. M.)

[I had been told by Mr. Roland Trimen that the South African native races commonly have a superstitious dread of this moth, and I was anxious to know whether this was the case in Rhodesia. The observation recorded below indicates very clearly that the sound and the attitude are the cause of the fear; for it was inspired in a native who had never before seen the moth. It is improbable that the moth is distasteful, but its legs are very powerful, and the spines on them sharp enough to cause an unpleasant prick even to human fingers. The behaviour of the *Cercopithecus* is strong evidence that the sound possesses a terrifying significance.—E. B. P.]

Salisbury, Jan. 11, 1901.—I was deeply interested in your investigations into the sounds produced by *A. atropos*, but I regret to say that I have never gone into the subject at all. The larva is fairly common with us, feeding on *Solanum* and foxglove, but the imago is not often seen. I showed one to some Mashonas the other day, and asked them if they knew it. "Oh yes!" they said, "it's an 'invemváne' [a general term for butterflies and moths]; it flies up in the air—whr-r-r-r—and the black man doesn't know how to catch it; only the white man can catch it." When asked if it were noxious, they seemed surprised and said, no, not at all. A Zulu replied in much the same way, and seemed to have no particular ideas about it. Some Zambesis said they did not know it, and when I suggested that it might be a "schelm" [a Dutch word for anything noxious or obnoxious], they said no, and one of them stepped forward and touched it with his finger. But when it arched its back and squeaked loudly, he jumped back in a fright saying: "Oh yes, boss, that's a 'skellem' right enough." I finally gave the insect to my monkey (*Cercopithecus pygerythrus*), making it squeak while doing so. He was evidently struck by the sound, and after watching a few moments grabbed it from my hand, bit off its head, and threw it down violently. He then approached cautiously, and began pulling it to pieces in a nervous spasmodic way, evidently fearing to get stung or bitten every moment; on tasting one of the bits he found it palatable and proceeded to eat it all. I should imagine that the curious movements and squeak of the moth are of a

terrifying character, or it may be really aposematic for certain mammals and birds, to which it may be distasteful. I cannot find from other sources that the Kafirs here have any superstitions with regard to it; the only insects they take any interest in seem to be the various beetles and larvæ which they eat.

26. INSECT STRIDULATION AS A WARNING OR INTIMIDATING CHARACTER. (G. A. K. M.)

Salisbury, April 19, 1901.—I have been thinking of trying to get some material together to support the view that stridulation in insects where occurring in both sexes may be explained in a large number of cases as a warning character, its value in this respect being especially well brought out in a number of obscurely-coloured Heteromera, etc., which are known to be distasteful, while it is largely absent in brightly-coloured, distasteful groups, as *Cetoniidæ*, *Mylabridæ*, *Lycidæ*, etc. I should also expect to find it more prevalent among distasteful nocturnal species, where warning colours are of little avail. One of my chief difficulties lies in the larval stridulating organs in Coleoptera referred to by Gahan in his interesting paper (Trans. Ent. Soc. Lond., 1900, p. 433), and I should be much interested if you could kindly tell me whether these larvæ really do stridulate, for I see that Sharp (Camb. Nat. Hist. Ins., Vol. II, p. 198) throws much doubt on the larval stridulation of *Melolonthidæ* and *Scarabæidæ* suggested by Schiödte. *Tucanus cervus* seems to be a well-authenticated case, and it would be most interesting to know whether the larva is distasteful. Darwin's suggestion as to the acquirement of stridulation by one sex and its subsequent transference to the other has always seemed to me unsatisfactory, and its possible warning value occurred to me immediately I began experimenting with Coleoptera. Of course in some cases it might be pseud-aposematic, as in Hymenoptera-like Longicorns in which it would suggest the shrill, angry buzz of a wasp. Pocock has already suggested this explanation with reference to scorpions and Mygale spiders, but I am not aware of any one else having referred to it.

[For this interesting investigation a piece of apparatus invented for me by my friend Mr. G. J. Burch, F.R.S., would be extremely useful. It consists of an ordinary double

stethoscope (for both ears) with the usual form of end-piece replaced by a cork traversed by a glass tube about one-eighth of an inch in internal diameter, and with its terminal lip very slightly expanded into a small funnel. If, while the ear-pieces are inserted in both ears, the open end be moved about near to a stridulating insect, an extraordinary reinforcement of sound takes place as the source is approached, so great indeed that I found no difficulty in localizing it within a small area. Excessively minute sounds become clearly audible by the use of this valuable and simple piece of apparatus. If there be good reason to suppose that the stridulation of any insect is inaudible to us, viz. if the structure of its organ and the movements set up as a result of irritation suggest stridulation, it would be feasible, I believe, to transmit the vibrations to some recording surface other than the tympanum of the human ear, and thus to investigate them.

It is usually possible to distinguish readily between the sounds which are emitted in courtship and those which are produced on irritation and are probably of a warning or terrifying significance, inasmuch as they arise from quite different stimuli and tend to be accompanied by characteristic movements or attitudes. This latter association is exhibited by the imago of *Acherontia atropos*, and the snapping sound made by its larva, due to the movements of the mandibles, is also of terrifying significance. I have once heard the epigamic sound of *Halias prasinana*, but only when the male was pursuing the female and the whole mode of flight was subordinated to the ends of courtship. Generally speaking, any sound produced by both sexes on irritation or attack, and accompanied by threatening attitudes or movements (as of the mandibles), or merely violent struggles, is to be interpreted, with a high degree of probability, as a warning or intimidating character. The decision between warning and intimidation can only be arrived at after an experimental investigation into the qualities of each separate species.

Pseudoposematic sounds are also well known in birds, especially those which build in holes in trees and hiss like a snake when disturbed. Many lizards also hiss when extremely irritated. Professor J. W. Gregory, F.R.S., describes a grasshopper at Kurawa which hissed so that he at first mistook it for a snake ("The Great Rift Valley," London, 1896, p. 273).—E. B. P.]

27. HUMAN EXPERIENCE OF THE TASTE AND SMELL OF INSECTS AFFORDS UNTRUSTWORTHY EVIDENCE OF THE EFFECT UPON THE SENSES OF INSECTIVOROUS ANIMALS. (E. B. P.)

The idea that human experience would supply a valuable test as to the palatability or unpalatability of insects to their natural foes has occurred to more than one naturalist. In Section 7 of his paper (Mém. de la Soc. Zool. de France, tome vii, 1894, p. 375, § 7), Professor Félix Plateau describes what he calls the "real taste" ("saveur réelle") of the larva, pupa, and imago of *Abraaxas grossulariata*: meaning by the words "real taste" the impression produced upon his own palate. After some natural hesitation he tasted a fine lively specimen of the larva, first cutting it transversely into two pieces. After masticating it sufficiently long to be sure of the impression produced, he affirms that it is almost without taste, very slightly sweetish, with nothing whatever unpleasant about it: "ni nauséabonde, ni poivrée, ni acide, ni amère, sans arrière-goût, et j'ajouterai même *agréable*, rappelant un peu celle des amandes douces sèches ou de la noix de coco." The skin is however somewhat tough, which Plateau suggests as a possible reason for the rejection of the larva by certain vertebrate enemies. The pupa was very similar, but even more tasteless than the larva; while the abdomen of the moth produced much the same effect when masticated: "la saveur m'a paru faible, *agréable* et analogue à celle de la chenille."

Plateau considers his experience to be entirely convincing and decisive as to the real taste of the insect to all insectivorous animals. But it is perfectly obvious that the only point which has been proved is that *a single individual of an animal not habitually insectivorous has found this insect to be rather pleasant in taste although decidedly insipid.* But this fact does not enable us to judge in any way of the impressions produced upon the senses of a truly insectivorous animal. That evidence must be judged upon its own merits, and, as Plateau appears to consider that he has shaken it, I give a somewhat detailed account of his treatment of the subject, and especially of his own valuable and interesting experiments, some of which were conducted upon insect-enemies hitherto unobserved and untried from this point of view. In view of the far-reaching character of Plateau's conclusion it becomes necessary to re-examine the

whole of the evidence for the unpalatability of *Abraxas grossulariata*, especially the larva, which has been chiefly employed for the purposes of experiment. Professor Plateau gives a fair and admirable résumé of the work of the earlier experimenters on the larva, showing that they arrived at the opinion that it was unpalatable, from the uniform behaviour of many European insectivorous animals, viz. many species of birds,* two species of spiders, the common frog, the tree frog, and many species of lizards. In describing the last experiments, those of F. E. Beddard, F.R.S., and F. Finn, conducted almost exclusively upon non-European animals ("Animal Coloration," London, 1892, pp. 149, 164, 165), the conclusion is omitted: "these experiments show that, with a few exceptions, the caterpillar of the magpie moth is distasteful to animals." Although a marmoset "ate one up quite greedily," the behaviour of two *Cebus* monkeys and a *Cercopithecus callitrichus*, as described by Mr. Beddard, is most suggestive of the errors likely to arise from a too-exclusive study of insectivorous animals able in confinement to eat but little, or nothing at all, of a food they would obtain in the wild state in plenty and variety. These monkeys "sucked at the caterpillar and threw away the skin after the contents had been entirely extracted; they paused every now and again to sniff suspiciously at the caterpillar, but nevertheless they steadily persevered in munching it." Mr. Beddard's account of the behaviour of non-European birds entirely confirms the conclusions derived from a study of European insect-eaters. It is probably safe to conclude that the species had never seen the larva before, and it is not surprising that many of them should peck at it. But although from Mr. Beddard's statement (*loc. cit.* p. 149) it is clear that over a dozen species were experimented upon, the only bird which certainly swallowed the larva was a large ground cuckoo (*Carpococcyx radiatus*). The author

* I am now glad to be able to add the evidence that a sparrow in the wild state rejected this moth after capturing it. The observation was made by my friend Mr. G. C. Griffiths, F.E.S., of Clifton, Bristol, a naturalist of great experience and powers of observation. Mr. Griffiths writes as follows:—"I was standing on June 30, 1900, among the trees on Clifton Down at mid-day, when a specimen of *A. grossulariata* flew out from a wych-elm and passed slowly across over a gravel path. A sparrow darted after it and bit off all its wings, but held its body scarcely an instant, dropping it upon the path, where I picked it up—a very satisfactory proof of its distastefulness."

is also "inclined to think" that a white-eye (*Zosterops*) ended by swallowing the insect after masticating it for a long time. The behaviour of the cuckoo is really confirmatory of previous observations, for it has been long known that our own cuckoo is a coarse feeder, and there is even evidence that it eats this very species, as pointed out by our President in the Annual Address for the present year (Proc. 1901, p. xli). The experiments made by Beddard and Finn on lizards support previous conclusions: "chewed and refused by *L. viridis*, and disregarded by *Zonurus* and *Amphibolurus*;" but they state that a toad ate the larva. From their other observations on these Amphibia, it appears certain that toads are indifferent to modes of defence which are efficacious against the majority of insect-eaters; but many more observations and experiments under various conditions are needed before we can safely conclude that *Abraxas* is palatable to these enemies. As possessing some bearing on the question, it is to be noted that a toad which had swallowed a caterpillar of *Euchelia jacobaeæ*, "almost immediately threw it up" (p. 159).

We now come to the more recent experiments of Professor Plateau. He found (§ 5) that eight *Cistudo europæa*, which were certainly insectivorous, inasmuch as they devoured beetles, paid no attention to the larva of *Abraxas*, with the exception of one individual which seized a larva and then abandoned it. *Coluber asculapii* and an Italian variety of *Lacerta muralis* paid no attention to them, and if, when one of them opened its mouth, a larva was inserted, it was immediately rejected. As regards Amphibia (§ 6), Professor Plateau found that the common frog acted exactly as Dr. A. G. Butler has described. He further believes that the frog never again attacks the caterpillar which it has once seized and rejected, although, as the larva walks off quite uninjured, the frog sometimes follows its movements for a few seconds. He then threw some larvæ into an aquarium containing a number of *Triton punctatus*, many of which seized and "made efforts to swallow them, giving, according to their custom, sharp blows with the head to right and left. But the prey was too big, or the skin too tough, for the Tritons abandoned them after a few minutes." The newt swallows its prey whole, and has great powers of expansion to meet the special difficulty of size, so it is far more probable that these Amphibia were influenced in the same manner as

the frogs and the water tortoises experimented on by Professor Plateau. He then offered the larvæ to the larger *Triton alpestris*, which paid no attention to them.

Professor Plateau's experiments on spiders are described on pp. 325-7, where it will be seen that the larvæ were either neglected or treated as A. G. Butler described by *Amaurobius ferox*, *Tegenaria domestica*, and *Agelena labyrinthica*. The imago on the other hand was constantly eaten by *Tegenaria*, offered once to *Epeira diadema* and eaten with avidity, killed but rejected by *Agelena*.

His experiments on *Carabus auratus* and two species of *Dytiscus* are described on p. 330: they indicate clearly that these predaceous beetles freely attack and devour both larva and imago of *Abraxas*.

The above is a résumé of the evidence as Plateau gives it, although he also includes the attacks of insect-parasites. These I have quoted on p. 338; but the other observations recorded in the same section of this memoir indicate that insects with warning colours and distasteful to the (non-parasitic) enemies of their class are specially liable to these attacks, so that the results obtained by Plateau in this section (§ 10) of his paper tend, so far as they go, to support the conclusions he seeks to destroy.

As regards the vertebrate enemies Plateau has supplied a considerable amount of evidence in support of the conclusions of his predecessors. He shows that certain spiders are probably, and some predaceous beetles almost certainly, enemies of *Abraxas* in one or more stages. These latter facts are most interesting and valuable, but they no more controvert or throw doubt upon the behaviour of the generality of insectivorous vertebrates than the admitted exception of the cuckoo, and the pleasant impression produced upon the Professor himself. All the theory of aposematic colouring requires is that the conspicuous form should be unfit as food for the majority of the enemies of its class; and this has been abundantly proved in the case of *Abraxas*. It is unimportant whether our anthropomorphic terms unpalatability, distastefulness, etc., truly express what an animal feels, if we admit the fact, as we are bound to do after the experiments, that the majority of insect-eaters after trial do not eat the insect, and after one or more trials do not seek to eat it unless driven by starvation. Exactly what impressions they feel we can never know, and it is quite unnecessary for the theory

of warning or aposematic coloration that we should know. The behaviour is sufficient, and affords convincing proof.

Plateau also brings two indirect lines of argument to bear on the question. He points out (§ 3) that the larva is not wholly conspicuous, but requires searching for if it is to be obtained in large numbers. This is due to its habit when young of resting along the serrated edges of leaves, exposing only the reddish lateral band sprinkled with black points. This appearance is at a little distance very like the reddish edges of many leaves. When it is older he observes that it stretches itself longitudinally along the branches in the inner darker part of the bush at no great height above the ground. When the bush is shaken it falls or lets itself down by a thread; and as soon as it reaches the ground rolls in a ring. In this position, which it retains for a long time, it resembles the excrement of a bird. Mr. Beddard too points out (*loc. cit.*, pp. 167, 168) that these larvæ "like other Geometers . . . do not begin to feed until evening. I have a quantity of these caterpillars on some thick-leaved shrubs in my garden; during the daytime none are visible, but in the evening they commence to crawl about quite actively." I have myself often observed the larva moving and freely exposed by day on the sides and tops of hedges, but after the statements of these two naturalists I am quite ready to believe that my observations were exceptional. Indeed on general grounds I must believe that this is so; for it would not be an advantage but a great disadvantage to the *Abraxas* to display its aposematic colouring at too great a distance. It has certain enemies, such as the cuckoo, and it would doubtless be dangerous if these were able to see it upon the bush at a great distance. Its colours would be conspicuous enough to the majority of insect enemies hunting the bush for food; and the *very* rough resemblance to leaf-edges, branches, and birds' excrement would never impose upon the eyes which enable their owners to find abundant food in spite of the extraordinarily close likeness to each one of these objects which is attained by so many of the cryptic species which they hunt.

Plateau's second indirect argument depends on the undoubted fact that the pupa of the *Abraxas* resembles a wasp. This he regards as an example of (Batesian) mimicry, and believes moreover that it has never been pointed out before. This is very far from being the case.

In my paper "The Experimental Proof of the Protective Value of Colour and Markings in Insects in Reference to their Vertebrate Enemies," Proc. Zool. Soc., 1887, p. 191, I published a Table (A) of the various combinations of colours of conspicuous insects. Section III of Table A, on pp. 232, 233, contained the combinations of black and yellow and of yellow and black; under the former was placed the pupa of *Abraxas grossulariata* and several Hymenoptera Aculeata, etc., under the latter the larva of *Euchelia jacobaeæ* and other species. Another Table (B) grouped conspicuous insects according to their patterns. Section I of Table B, on p. 236, is as follows:—

I.—*Ring Pattern.*

Pattern developed on abdominal segments.	{	Pupa of <i>A. grossulariata</i> .	{	Alternating rings of yellow and black.
		Imago of <i>Vespa</i> , <i>Nomada</i> , and <i>Bombus</i> .		
Developed on whole length of body.	Larva of <i>E. jacobaeæ</i> .			

The following sentences refer to this very section of Table B:—"There is probably in some cases a certain amount of true mimicry in the acquisition of patterns and colours. Thus it is more than probable (as has been previously suggested by other observers) that the species rendered conspicuous by alternate rings of black and yellow gain great advantages from the justly respected appearance of hornets and wasps. It must not be forgotten, however, that the latter forms also probably gain to some extent by the greater publicity which follows from the resemblance" (pp. 235, 238). Furthermore in 1890 the same conclusions were re-stated in almost the same words, save that the species indicated in Table B, Section I, are here introduced into the text:—"Thus it is more than probable that the species marked by alternate rings of black and yellow (including the chrysalis of the Magpie Moth and the caterpillar of the Cinnabar Moth) gain considerable advantages, etc." ("Colours of Animals," London, p. 186).

It is hardly necessary to point out that the resemblance to a wasp is no evidence of palatability, any more than the resemblance, which is often strongly marked, in the same district between wasps of different genera and between

them and Hymenoptera Aculeata of other sections. The present memoir contains splendid examples of Müllerian or synaposematic associations between inedible forms such as *Lycidae* and stinging Aculeates (see p. 517), and the resemblance between *Abraxas* and a wasp is probably of the same kind, as I suggested in 1887.

My friend Professor W. M. Wheeler of the University of Texas has also tasted a Syrphid fly, *Spilomyia fusca* (Loew), which mimics *Vespa maculata* as well as a smaller wasp. The fly was "found to have an agreeable flavour, the alimentary tract of the insect being full of honey." Hence in this case Professor Wheeler concludes that the colours of the fly are "associated with the absence of disagreeable smell and taste, as the generally accepted theory of mimicry requires" ("Science," N. S. vol. vi, No. 154, p. 887, Dec. 10, 1897). Still later in "The Century Magazine" for July 1901, p. 378, Professor Wheeler describes another experiment as follows:—"The writer while riding through the deserts of Wyoming some years ago was impressed with the day-flying moths (*Pseudohazis*) flitting leisurely along near the ground or resting fully exposed on the glaucous spikes of the sage-brush. . . . They had black-and-white wings and black-and-orange bodies. So striking was this case of apparent warning colour that the writer after much hesitation decided to ascertain by means of the only available experiment whether the insect really possessed the 'nauseous properties' so generally assumed in such cases by writers on the subject of animal coloration. He dismounted from his horse and proceeded to masticate the body of one of the moths. To his astonishment, the little flavour that it contained was mild and pleasant—one might almost say, nut-like." The writer also records that lizards previously fed on house-flies, and therefore not very hungry, "devoured with evident signs of relish" several of the conspicuous day-flying moths *Alypia octomaculata*. Professor Wheeler concludes "that if every field-entomologist could only bring himself to repeat the writer's experiment on *one* of many cases of 'flaunted nauseness,' and place his taste-impressions on record, we should in the course of time have a really valuable body of evidence, for we can hardly assume that beasts, birds, and reptiles can find things 'nauseous' which are quite tasteless or even pleasant to the human palate."

I believe, on the contrary, that we are justified in the opinion expressed in the last words quoted from Professor Wheeler, and I have proved that we have very good grounds for maintaining that a conspicuous insect pleasant to the human taste is rejected with probable signs of disapproval by many truly insectivorous animals. The tasting of conspicuously coloured insects by entomologists in general, recommended by Professor Wheeler, would I believe be of very little value or more probably of no value at all as evidence of the likes and dislikes of insect-eating animals. Carefully conducted experiments upon such animals, and still better observation of them and their prey in the field, and the examination of the contents of their digestive canal and the components of their fæces, are the only means by which trustworthy conclusions can be reached. We have to deal with a heterogeneous group of animals, alike in one respect, viz. the specialization of digestive apparatus and sense-organs to an insect diet. It is reasonable to suppose that, whatever we may find in man and other forms not markedly insectivorous, in the members of this particular group there will be a specially acute sensitiveness to qualitative differences amongst the innumerable species from which they select their food. It is probable that especial keenness for certain species indicates a high nutritive value, and that the sense-organs of insectivorous animals enable them to detect and thus to reject species which would have an injurious effect, or at the least would be of comparatively low value as food. There is no reason for the belief that an equal degree of specialization exists in animals which are not insectivorous. Least of all is this likely to be the case in man, with his comparatively minute olfactory lobes, the central organ by which there is appreciation of every kind of flavour as well as every variety of scent.

I have thought it desirable to argue the question at some length, inasmuch as the two distinguished naturalists I have quoted, as well as others, find significance in human experience of the taste of insects. The opposite conclusion has always seemed to me inevitable from the considerations set forth above; but if any doubt remains it must be dispelled by reading the following account of Mr. Marshall's experiments upon himself, and comparing it with those which he conducted upon insect-eating animals of many kinds. It is interesting that he should detect bitterness,

acridity, and a Coccinellid-like smell in certain species, but even in these the human experience is probably very faint compared to that of a truly insectivorous animal. Nor does it by any means follow that a scent which is excessively unpleasant to man indicates unpalatability to all or even the majority of natural foes, as in the obvious case of *Anoplocnemis curripes*, the evil-smelling Coreid bug eaten greedily by baboons (see p. 382), although rejected after tasting by a kestrel (p. 345). Professor Plateau and Professor Wheeler will probably reconsider the significance of their own sense-impressions when they read below that Mr. Marshall could detect nothing unpleasant in the much-mimicked *Limnas chrysippus*.

"*Estcourt, Oct. 15, 1896.*—I have for some time intended to make experiments on the taste of the *Acræas*. . . . However, my tasting experiments have not helped me much, for my sense of taste is evidently not as acute as that of birds and lizards. However, I send you the few notes I have made in case they may be of interest or use.

"In *Acræa nohara*, *buxtoni*, *cabira*, and *Planema esebria*, I was unable to detect any trace of bitterness or acridity, and they appeared to me quite insipid; indeed, as far as mere taste is concerned, I doubt whether I could distinguish them from *Belenois severina*, though their outer integuments are much tougher. [Mr. Marshall subsequently found that *buxtoni* does possess a bitter juice, which exudes freely from the wings when they are cut, especially at the bases.] This alone is sufficient to prove the unreliability of the test, for *cabira* is most certainly an inedible species, even if *esebria* is doubtful. *A. encedon* and its var. *lycia* exude a yellow juice from the thorax which is slightly bitter, but not very markedly so. *Acræa anacreon* and *natalica* both exude juice in the same manner, but it seems distinctly more bitter than that of *encedon*. *A. anemosa* in addition to the bitter juice emits a very strong smell when pinched, being the only *Acræa* in which I have noticed this, though possibly *acara* does the same, as I regard these as the two best-protected members of the genus. *Planema aganice* has no smell, but emits a lot of acrid juice, not only from the thorax, but also from the antennæ and the nervules of the hind-wings. With regard to the juice-exuding species I may note that the bitter taste appears to lie only in the exudation and not to permeate the tissues of the body.

"In the few specimens of *Amauris echeria* that I tried I found that no juice was emitted, but they had a nauseous taste and a strong smell, which reminded me somewhat of that emitted by many *Coccinellidæ*. But it was *L. chrysippus* which showed me the futility of trying to arrive at any definite conclusions from this line of research, for it emits neither juice nor smell, and I could detect no trace of any taste, unpalatable or otherwise, but the tissues have a somewhat soapy feel to the tongue, which I noticed in *A. echeria* and some of the *Acræas*. The same may be said of *Mylothris agathina*, though from its conspicuous colouring, slow flight, and wide dispersal, I feel sure it is an inedible species.

"*Malvern, Feb. 21, 1897.*—*Acræa horta* exudes a bitter yellow juice from the thorax when it is injured, and this juice permeates the costa of the fore-wing. The head and abdomen do not appear to me to have any unpleasant taste. Trimen refers to their smell, but my smelling powers are not sufficiently acute to detect it.

"*Malvern, May 14, 1897.*—*Alæna amazoula* feigns death most persistently; it has an unpleasant taste and strong smell not unlike that of the *Coccinellidæ*."

28. GUY A. K. MARSHALL'S PROOF OF SEASONAL CHANGES IN SOUTH AFRICAN BUTTERFLIES OF THE GENUS *Precis*. (E. B. P.)

A. Introduction.

The attempt will be made in the following section of this memoir to explain these astonishing changes as due to the adaptation of a moderately distasteful and protected genus in two directions—towards conspicuous warning colours in the generations of the wet season, the time when insect-food is abundant; towards procrryptic concealment in the pressure and scarcity of the dry season.

Facts which require for their interpretation the hypothesis of adaptation in the direction of conspicuousness will be brought forward, much use being made of the conclusive proof only recently obtained by Mr. Marshall, by breeding the one from the other, that *Precis simia* is the wet phase of *P. antilope*.

The distinct habits and stations of the two phases, their relation to other seasonal forms of butterflies, the observed

differences in the insect life of the two seasons, will all be shown to be consistent with the above hypothesis.

The results of Mr. Marshall's experiments as to the nature of the stimulus by which the change is started in any individual will be discussed, and further lines of investigation suggested. The much greater size and weight of the dry phases will be shown to have an important bearing upon the inquiry, indicating, as it does, that the phase must be predetermined in the larval stage.

Finally, it will be argued that the facts proved by Mr. Marshall, although most startling and indeed astounding, are not subversive of any of the principles of the science of systematics.

B. *Historical.*

In his great work on "South African Butterflies" (London, 1887, vol. i), Mr. Roland Trimen describes several intermediate varieties between *Precis natalensis* and *P. sesamus*, and records Mr. F. N. Streatfeild's capture of the two butterflies *in coitu*. He concludes (*loc. cit.* pp. 231 and 233), "It is only to such occasional unions, and to their fertility, that the origin of the intermediate examples under notice can be attributed."

Mr. Trimen also makes a similar suggestion as to the intermediate varieties between *pelasgis* and *archesia*, which are also recorded as having been taken *in coitu* (*loc. cit.* p. 235).

Mr. Guy A. K. Marshall first published in 1896 the suggestion that a group of South African butterflies described and known as different species of the genus *Precis* or *Junonia* were in reality the seasonal phases of a comparatively limited number of species. He pointed out, however, that *octavia* and *amestris* (*s. l.*) had been previously considered as two forms of a single species by M. Charles Oberthür of Rennes (*Ann. Mus. Genov.* xviii, 1883, p. 721), and also that Mr. C. N. Barker, the distinguished Natal naturalist, had been long convinced of the existence of these seasonal phases, and especially of the most remarkable case of all, *P. sesamus*, and its wet-season form, *natalensis*.

Mr. Marshall's general description of the differences between the two phases is as follows: "The dry-season form is smaller, and usually assumes a duller type of colouring on the upper-side, sometimes of quite a different hue; the

under-side becomes of a general brownish tint, more or less resembling a withered leaf, the likeness being heightened by an oblique line running from the apex of fore-wing to the anal angle of hind-wing, representing the mid-rib; also by the marked prolongation of the fore-wing, so well known in the winter form of *Melanitis leda*. Lastly, the ocelli on the under-side are much reduced or obsolescent" (Trans. Ent. Soc. Lond., 1896, p. 557). I am unable to understand the opening statement that "the dry-season form is smaller," indeed, Mr. Marshall criticizes a more general statement of the same kind made by Mr. C. N. Barker (*loc. cit.* p. 551). In the very first species described from this point of view by Mr. Marshall, *Precis tugela*, he speaks of "the smaller summer form," and the only other *Precis* in which he speaks of a difference in size is *P. artaxia*, of which he uses almost the same words (p. 561). I have since compared the two phases of the following species in the Hope Collection, with results shown below:—

<i>Precis tugela</i> , dry phase larger.				
"	<i>ceryne</i> ,	"	"	much larger.
"	<i>actia</i> ,	"	"	" "
"	<i>pelasgis</i> ,	"	"	rather "
"	<i>sesamus</i> ,	"	"	distinctly larger.*
"	<i>antelope</i> ,	"	"	much "
"	<i>artaxia</i> ,	"	"	" "

See also pages 451 and 456 for the proof by weighing of the great difference between some of these phases.

Since the above paragraph was written Mr. Marshall has informed me that the statement was certainly a slip of the pen, which remained uncorrected, because he was unfortunately unable to see the proofs of his paper.

Although Mr. Marshall anticipated the results of future discovery in a truly remarkable manner in this memoir (Trans. Ent. Soc. Lond., 1896, p. 557), and brought forward evidence of a most convincing kind, yet the conclusion which required to be proved was to most naturalists so highly improbable, because of the extraordinary differences between the supposed species, that nothing less than the actual breeding of one form from another was sufficient.

In his second paper on the subject (Ann. and Mag. Nat.

* Difference much less marked in specimens from northern part of range.

Hist., ser. 7, vol. ii, July 1898, p. 30), which it is only just to describe as epoch-making in the history of seasonal dimorphism, Mr. Marshall recorded this great discovery, and published the fact that he had succeeded in breeding *sesamus* from *natalensis* in three cases. The specimens themselves Mr. Marshall presented in two cases to the Hope Collection at Oxford, in the third to the British Museum of Natural History. The Oxford specimens are figured on Plate XII, figs. 1 and 2 the parents, figs. 1*a*, 1*b*, and 2*a* the offspring. The dates of the various stages are given in the description of the plate.

These specimens must always have historic interest, and I have therefore published in the plates accompanying this memoir a representation of the whole of the evidence obtained by Mr. Marshall in 1898, so far as it is at my disposal. The extracts from Mr. Marshall's letters bearing on the same subject have also historic interest, and are therefore recorded in full below.

"*Umkomaas Mouth, Natal; Sept. 3, 1897.*—I am sorry to say I have never yet bred *natalensis* through to *sesamus*. At Karkloof, Natal, I managed to secure three eggs in March (just the right month for the purpose of testing the hypothesis that they are the same species), and one of the resulting larvæ was fully half-grown when I left there for Malvern, near Durban. I brought them down with me, as I knew that C. N. Barker had bred *natalensis* from the larva, and so would know their local food-plant. The Karkloof plant does not occur at Malvern, and the larvæ utterly refused the Malvern food-plant and everything else I tried them with; so they pined away and died.

"I have not the least doubt of the specific identity of these two forms; they are undoubtedly confined respectively to the wet and dry seasons, they have been frequently observed *in coitu*, and intermediate forms occur at the change of seasons. The larvæ are identical and feed on the same plant; for out of twelve larvæ taken by Hutchinson off one plant, ten were *natalensis* and two *sesamus*. I always think *natalensis* is an interesting species as showing the brilliant colours which can be acquired by an unprotected species without detriment. A newly-emerged *natalensis* is a glorious insect, and rivals the brightest *Acraeas* in its colouring on both surfaces; moreover, it is a frequenter of open country, where its salmon-red wings

are a conspicuous object as it sits sunning itself on plants or stones. But it is very wary and difficult of approach, being kept on the alert by its enemies, the lizards. I have often watched these little reptiles stalking both *natalensis* and *pelasgis* round the stones, and have seen them capture and eat both species."

"Salisbury, March 6, 1898.—You will be pleased to learn that within another few weeks I hope to have been able to have solved the *natalensis-sesamus* question. Three weeks ago I obtained five eggs from a female of typical *natalensis*; two proved infertile, one young larva I lost, but the remaining two are thriving and growing splendidly. Later on I got three more eggs, which have hatched successfully. To-day I took one more, and also, which pleased me much, an egg of typical *Preccis simia*, which I am convinced is the wet-season form of *P. euama* (Hew.), in spite of Butler's remarks. The *natalensis* question I am all the more anxious to settle, as I have now strong collector's evidence against me, viz. Distant, who records that he only took one *natalensis* at Pretoria, whereas *sesamus* was abundant and occurred all through the wet season."

"Salisbury, June 5, 1898.—You will be glad to learn that I have at last proved the identity of *P. sesamus* and *natalensis* by breeding the former from eggs laid by the latter in three instances, and I send you the parent and offspring in two of the cases, the third I am sending to the British Museum. You may imagine my delight on seeing the first specimen emerge, for though I felt convinced that the result would be as I anticipated, yet Distant's remarks raised a haunting fear that perhaps I had made a big mistake after all. However, I am glad to say this was not so."

C. *The Demonstration by GUY A. K. MARSHALL that Precis simia is the Wet Phase of P. antilope.*

Only a few weeks ago Mr. Marshall obtained this further proof of the soundness of the conclusions he reached, and the validity of the evidence he adduced in 1896. A female specimen of *P. simia* was tracked while she laid nine eggs, on Feb. 23, 1902, at Salisbury. The butterfly was then captured, and is represented on Plate XII, fig. 3, and the under-side on Plate XIII, fig. 4. Offspring of

the form *antelope* were successfully reared from two of these eggs. In the case of the first, shown on Plate XII, fig. 3*a* (under-side on Plate XIII, fig. 4*a*), the egg hatched on March 1, the larva pupated on April 10, and the imago, a female, emerged on April 27. In the case of the second, shown on Plate XII, fig. 3*b* (under-side on Plate XIII, fig. 4*b*), the egg hatched on March 1, the larva pupated on April 14, and the imago, a male, emerged on April 29. All three specimens have been presented by Mr. Marshall to the Hope Collection at Oxford. The great difference between the under-sides of the two offspring (compare Fig. 4*a* with 4*b* on Plate XIII) is deeply interesting. Although so widely different, both equally resemble dead leaves, recalling the various distinct forms of dead leaf represented by the under-sides of the individuals of the same species of *Kallima*. The difference between the outline of the wings in parent and offspring is seen to be far greater in this species than in *sesamius* and *natalensis*, and *archesia* and *pelasgis*, as will be at once seen when the figures on Plate XII or Plate XIII are compared.

Mr. Marshall's account of his success in obtaining the material by which he proved the identity of *antelope* and *simia*, was received in the following paragraph of one of his letters.

"*Salisbury, Feb. 26, 1902.*—I cannot even now agree with Butler's arrangement of *Prexys antelope* and *cuama*. For although their extreme forms appear to be very distinct, yet all the chief distinctive characters are unstable and tend to converge. Aurivillius agrees with me in regarding them as conspecific, though he separates *trimeni* and *simia*. A pair of these latter I took *in copulâ* last season, which is sufficient evidence as to their identity in my mind, for I am very sceptical as to interbreeding in a case such as this. However, I have determined to solve the problem this season, and since my return most of my time out-of-doors has been spent in trying to secure authenticated eggs of either summer form. Last Sunday I succeeded at last! I got nine eggs from a single *simia*, and they will probably hatch to-morrow; I hope I shall succeed in pulling most of them through. All my larvæ died in the first stage last year, for owing to the erratic way in which the females lay I could not ascertain the true food-plant, but I think I have it all right this time. I expect to breed both

antelope and *euama* from these eggs, as these forms are just beginning to appear."

As explained above, both pupæ emerged as *antelope*.*

D. *The Habits of the two Seasonal Phases of the South African Species of the Genus Precis, and the Stations which they respectively occupy.*

That these butterflies should exhibit a marked difference in habit and station corresponding to a difference in appearance at the wet, as compared with the dry season, is of such paramount importance in the consideration of the significance of these phenomena, that I quote at length all available observations of naturalists—some of them made before there was any suspicion that such forms as *scsamus* and *natalensis* were the two phases of a single species.

In "South African Butterflies," vol. i, London, 1887, p. 230, Mr. Roland Trimen, F.R.S., speaks of the habits of *Precis octavia* [*natalensis*, ⊕ wet phase], as he had seen it "widely spread over Natal in the summer of 1867. It frequents open, grassy hills, especially their summit ridges or highest points, and is very conspicuous, whether flying or settled."

Of the habits of *P. scsamus* ⊙ he writes (p. 233): "Though constantly to be seen flitting about with its congeners, *octavia*, *archesia*, and *pelasgis*, I have noticed that *scsamus* has a greater liking than any of them for shady places, preferring to settle under a bank or in some deep road-cutting. . . . The very dark bronzy-green under-side is well adapted for concealment in such spots."

Of *Precis archesia* (dry), he notes that it "delights to bask or repose on rocks or large stones. Colonel Bowker has noted that it sometimes congregates under rocks, and is often met with in small rocky caverns in deep forest kloofs." Mr. Trimen has noticed at Highlands, near Grahamstown, "a habit in the ♂ *pelasgis* [wet] which I have never witnessed in the case of *archesia* [dry], viz. that of perching himself on the projecting twig of some

* ["Although I am still of opinion that Dr. Butler is in error in regarding *antelope* and *euama* as distinct species, yet it may be pointed out that the results of this experiment do not in any way disprove his contentions."—G. A. K. M.]

high bush at the edge of a wood, and thence giving chase to other passing butterflies" (p. 237).

In suggesting the seasonal relationships in the genus *Precis* which he afterwards proved to exist, Mr. Marshall speaks at the beginning of his first paper on the subject (Trans. Ent. Soc. Lond., 1896, p. 557) of the special interest which attaches to the alternations in this genus, "not only on account of the great differences in the colouring of their two forms, but also because of their marked change in habits."

He points out that the species of *Precis* in which there is but little seasonal change (*P. tugela*, *P. elgiva*, and *P. natalica*) are, when at rest, leaf-like in both phases, although they are more leaf-like in the dry season. He states that they are furthermore especially forest insects, being confined to "the warmer, low-lying, or heavily-timbered districts." The other species of *Precis* in which the seasonal forms are very different "occur more abundantly, or even exclusively, in the uplands and in open country." There are, however, differences of habit in the species of the former group. Thus Mr. J. M. Hutchinson is quoted by Mr. Marshall as stating that the summer form of *P. tugela* "is a bolder insect, sailing around and settling on trees at a fair height, almost after the manner of *Charaxes*, whereas the other is much more retiring, keeping among the thick bush and settling low down, or on the ground among dead leaves, etc." (*loc. cit.*, p. 558).

Turning to the second group of species in which the seasonal changes are pronounced, Mr. Marshall describes the habits of *P. simia* [*antilope*] (*loc. cit.*, p. 560): "The dry-season form only frequents the bush, settling on the ground among the dead leaves, or very rarely on small plants, the under-side colouring affording it excellent protection. As the season advances the habits of the insect change, and in October and November the later form (*c*) may be found in company with the early form of *simia* (*b*), frequenting open tops of kopjes, flying boldly about within a limited area, and settling with expanded wings on shrubs and bushes. This is the habit of all summer forms of *Precis*. . . ." With regard to *P. sesamius* ☉, Mr. Marshall remarks that it "differs from the normal type of winter *Precis* in the absence of leaf-like colouring below, and in the very slight falcation of fore-wings. This

is accounted for by its different habits, for instead of frequenting dead leaves in the bush it prefers the dark rocks on stony and wooded kopjes." Evidence is brought forward to show that *P. artaxia* only exists in the cryptic dry phase in the warm timbered coast belt, although it develops a much less well-concealed wet-season phase (*nachtigalii*) in open country (pp. 561, 562).

In his second paper on the subject (Ann. and Mag. Nat. Hist., ser. 7, vol. ii, July 1898, p. 30) Mr. Marshall gives a further account of these interesting differences in habits: "Speaking broadly, the *natalensis* form frequents the highest points in any neighbourhood, especially if they be more or less open (for it is anything but a sylvan insect); whereas the *sesamus* form is more partial to shady spots, and is to be found in ravines and spruits or rocky wooded slopes, and shares with the Hesperid *Sarangesa eliminata* a marked affection for disused mine-shafts and cuttings. This distinction must not be taken too strictly, for true *sesamus* is occasionally found in company with the summer form on open hill-tops, but principally at the change of seasons; but *natalensis*, so far as my experience goes, is never to be found in the more shady stations frequented by *sesamus*. The latter, moreover, is distinctly warier and more difficult of approach when not feeding, and if alarmed flies off with a rapid, and often zigzag, flight, settling abruptly among rocks or herbage, when its greenish-black under-side colouring is equally protective. *Sesamus* is more often observed in gardens, and not unfrequently enters human habitations in search of a shady resting-place." Mr. Marshall also quotes Mr. J. M. Hutchinson's experience on his farm in Natal, lying in an open plain between two ranges of hills: "He has found *sesamus* resident on the farm, occurring fairly commonly along the banks of the spruits during the winter, whereas *natalensis* is very much scarcer and non-resident, the examples seen having always been travelling from one range of hills to the other, on both of which it is common."

Since his return to England, in the present summer, Mr. Marshall has summarized his experience of the habits and stations of the seasonal phases of the species under discussion as follows:—

"There are three types of stations in South Africa which may be occupied by butterflies of this genus.

I. *Forest country*, with heavy timber affording deep

shade. Found on the coast belt and also in the interior, but, south of the Zambesi, only in patches.

II. *Woodland country*, without timber. Trees small, affording light shade.

III. *Open country*, without trees. Nothing higher than small scrub.

I. The following species are only found in the forest:—

1. *P. tugela*. It has been already explained that the wet-season form exposes itself more freely (p. 421). Both phases have leaf-like under-sides, but the dry has a more hooked tip to fore-wing and more prolonged anal angle to hind-wing.

2. *P. elgiva*. No difference in habits observed. The slight differences in appearance are due to a more hooked tip with a somewhat different direction, and a more leaf-like under-side in the dry phase as compared with the wet.

3. *P. natalica*. No difference in habits observed, both phases being low settlers. Ocelli and white spots on the under-side tend to disappear in the dry phase.

II. The following species are found in the woodland country:—

1, and 2, *P. antilope* and *P. actia*. In both these species the dry-season phase and the female of the wet are found in the more shady places, viz. the lower slopes of kopjes. The ♂ of the wet phase is usually found on the less-wooded higher slopes.

3. *P. artaxia*. The habits are like those of the two preceding species. Towards the forest belt in Umtali the dry phase encroaches on the wet, and in the low country between Umtali and the sea Selous never saw the wet form at all. The larger dry form has a *far* more leaf-like under-side, with a mid-rib, and hooked tip to the fore-wing, wanting in the wet. The dry phase is also more wary.

II. and III. The following species are found in open as well as woodland country:—

1, and 2, *P. sesamus* and *P. archesia* have very similar habits. The dry phase generally frequents the wooded and the wet phase the open country. In entirely open country the former would occur on the lower slopes in whatever shade is to be found. In entirely woodland country the dry phase would be found on

the lower, more shady slopes, the wet on the upper slopes where there is less shade.

III. The following species only occurs (in Mashonaland) in open country :—

1. *P. ceryne*. Both forms are found in open swampy districts, without bush. Rare."

E. *Evidence of Adaptation in the conspicuous under-sides of the Wet-Season Phases almost equal to the proof of it in the cryptic Dry Phases.*

The evidence of adaptation in the cryptic under-sides of the dry phase in the species under discussion is so clear and so generally admitted that it is unnecessary to say much about it. I will only point to the manner in which the various distinctive elements of this phase are co-ordinated to a common end, that of concealment. Thus in the dead-leaf-like forms such as *archesia* and *antelope* we find the prolonged anal angle of the hind-wing, the produced and bent apex of the fore-wing, the angulated outline between these points, the stripe representing a mid-rib, the colours and patterns varying in different individuals but always resembling some type of dead leaf with discoloured blotches or eaten into holes (*archesia*). Most important of all there is the co-ordination of all these diverse elements with appropriate habits and the choice of an appropriate station. In *archesia*, which commonly frequents rocks, the intensely variable mottled appearance produces a strongly cryptic effect at a little distance, while a close inspection only brings out the details which produce a graphic representation of a dead leaf. In *sesamus* the outline and under-side differ from those of the dead-leaf-like dry phases of the other species, and differ in a direction which is specially cryptic, because of the peculiar habits of this phase of the species (see pp. 420, 422).

All this will be at once admitted by every naturalist who studies the specimens, as it is proclaimed by all who have had the advantage of observing the species in the wild state. What is not admitted, but is I think almost equally clear, is the fact that adaptation in the opposite direction, viz. the direction of conspicuousness, is characteristic of the under-sides of the wet phase. If the under-side merely reproduced the conspicuous pattern of the upper-

side of the wet phase the case would be strong and convincing for adaptation, and an interpretation based on the principles of warning colours or mimicry, Batesian or Müllerian. But the under-side does more than this; it differs from the upper-side, and so far as it differs, it becomes *more conspicuous*. The following details render the case for adaptation in the direction of conspicuousness, as it seems to me, overwhelming.

In comparing the upper- and under-side of the wet phase of the species to which the chief attention of naturalists has been directed, it is of special interest to turn to the accurate descriptions of Mr. Roland Trimen, F.R.S., written long before Mr. Marshall's discovery was thought of, a time when *natalensis* and *sesamus* were not only considered distinct but were even separated by *ceryne*. In "*Rhopalocera Africæ Australis*" (London, 1862-66) we read, on pages 130, 131, of *Junonia octavia* [*Precis sesamus* ⊕]: "UNDER-SIDE.—*Much paler, more creamy in tint, with a glistening pinkish tinge.*" Again, on the under-side of the fore-wing the author speaks of "the row of spots parallel to hind-margin commencing distinctly *from costa*, the first two spots increasing the number to seven; double row of bluish lunules more conspicuous than on *upper-side*, whiter." And the under-side of the hind-wing is thus described: "Basal black *containing four rather large, very conspicuous spots of the ground-colour*, and dusted with blue scales, which form a transverse streak between costal and subcostal nervures near extremity of black; whitish-bluish lunules, in hind marginal border, large and very conspicuous." The fact that the ground-colour of the under-side is much paler than the salmon-red of the upper and thus affords a far more effective contrast with the black markings is seen when Fig. 1 on Plate XIII is compared with Fig. 1*b* on Plate XII. Figs. 1 and 2 on Plate XII represent worn specimens, and the comparison with them is invalid. Fig 1*b*, Plate XII, possesses unusually heavy black markings, but the representation of the depth of the red ground-colour is normal for a fresh individual, as is that of the under-side in Fig. 1, Plate XIII. The more complete row of black spots and the greater conspicuousness of the border, owing to the larger white and blue markings in it, as described by Trimen, are also well seen when the figures are compared, but allowance must be

made for the fact that the border represented in Fig. 1b, Plate XII, is exceptionally broad, and is still more exceptional, indeed transitional towards *sesamus*, in the size of the blue markings in it. But the lighter character of the markings and the more conspicuous appearance of the under-side border is perfectly clear in Fig. 1, Plate XIII. And there is one other point not expressly mentioned although probably implied by Mr. Trimen, which is I think the most convincing evidence of all in favour of adaptation in the direction of conspicuousness;—the fact that the spots of ground-colour included in the basal black patch of the hind-wing, and absent from the upper-side, are distinctly lighter in tint than the rest of the ground-colour, and thus afford a far more effective contrast with the black. This difference in tint is well seen in Fig. 1, Plate XIII. The spot in the basal black of the fore-wing which represents a similarly-placed spot on the upper-side, is also often lighter than the rest of the under-side ground-colour, but the difference is far less marked than in the hind-wing and is sometimes absent.

Now the basal area of the under-side of butterflies' wings and especially of the exposed hind-wing is a part specially seized upon by natural selection for the display of conspicuous warning characters. It is seen in the red patches of many Pierine genera, especially the distasteful *Delias* (appearing also in its Chalcosid mimics) in the Old World, and several *Pierinae* in the New, where Dr. F. A. Dixey has shown that the character has probably been adopted by *Heliconinae* in Müllerian association with them, the relationship—an important discovery first made in 1894 by Dixey—being one of "reciprocal assimilation" or "diaposematic resemblance" (Trans. Ent. Soc. Lond., 1894, pp. 296–298; 1896, pp. 72–74; 1897, pp. 326, 327, 331; Proc. Ent. Soc., 1897, p. xxix). A stripe of bright yellow or red bordering the basal part of the costal margin of the under-side of the hind-wing of a large number of distasteful tropical American butterflies of different sub-families is another very characteristic synaposeme, rendering the same part of the wing especially conspicuous. And in Africa itself we have the most remarkable case of all, in the triangular golden-brown, black-marked synaposeme which is discussed at some length on pages 488 to 490 of the present memoir. Furthermore, there is the group

of large black spots on a light ground which renders this part of the wing prominent in such large numbers of Ethiopian butterflies.

In the wet phase of *Precis sesamus* this area is also remarkably conspicuous, but by a method which is as positive to negative in relation to other distasteful butterflies inhabiting the same part of the world, viz. by the appearance of light spots on a black ground, instead of black spots on a light ground.

Thus it is improbable that this particular element in the conspicuous appearance of the under-side of the wet phase of *P. sesamus* can be mimetic, and its existence, side by side with a general resemblance in colour and pattern to a large *Acræa*, is evidence that such resemblance is Müllerian or synaposematic rather than Batesian or pseudaposematic. This argument is much strengthened by the discussion of the wet phase of the allied *P. archesia* (see pp. 428-430).

Much that has been said of *P. sesamus* applies with greater force to the closely-allied *P. antilope*. On comparing the under-side of the wet phase, shown in Fig. 4, Plate XIII, with the upper-side of the same specimen, shown in Fig. 3, Plate XII, it is at once seen that the difference in tint of the ground-colour and in conspicuousness of the marginal band on the two wing surfaces is far more pronounced than in the species which has been just described. In fact, with an upper-side which is much less conspicuous than *sesamus* \oplus (compare Figs. 3 and 1b, Plate XII: it must be remembered that the ground-colour of 3 is merely tawny, while that of 1b is salmon-red), the wet phase of *antilope* combines an under-side which is distinctly more conspicuous than that of the corresponding form of the allied larger species (compare Figs. 4 and 1, Plate XIII). The increased conspicuousness is especially clear in the relative size of the spots in the basal black patch and the inclusion in it of a very large piece of the ground-colour of the fore-wing. Here too the increased lightness of the spots of ground-colour in the black area is often distinct, as it is in Fig. 4, Plate XIII, but in a large proportion of the individuals I have had the opportunity of examining it is only feebly marked.

In *P. antilope* \oplus there is probably some considerable synaposematic approach towards the *Acræa* type, but to a less extent than in *P. sesamus*; while the conspicuous basal

character which is non-acræiform and purely aposematic is far more emphasized than in the latter species. It is probable that *sesamus* represents a later development, and that in it the synaposematic elements have been gradually strengthened and the peculiar aposematic character correspondingly reduced.

We now pass to the consideration of a species in which the conspicuous characters of the under-side of the wet phase are probably entirely peculiar and aposematic.

Mr. Marshall's suggestion in 1896 that *Precis pelaspis* is the wet phase of *P. archesia* has never been confirmed by breeding the one form from the other. It is, however, certain that his conclusion was sound. The two forms have often been captured *in coitu*. The female *pelaspis* represented in Plate XII, fig. 4, was captured by Mr. Marshall *in coitu* with the male *archesia* shown in Fig. 5 of the same plate. Intermediate forms are much commoner than in the case of *sesamus* and *antelope*; and above all the relationship of wet phase to dry is far closer in *archesia*, so that it is possible to see how the one was derived from the other more fully than in any of the species with markedly-different seasonal forms. The under-side of one of the commonest forms of the dry phase is represented in Fig. 6, Plate XIII, and opposite to it that of the typical wet phase in Fig. 5. At first sight they appear totally different, and certainly the latter is as conspicuous as the former is well concealed. An uncoloured illustration cannot do justice to the varied shades of brown and grey on the under-side of *archesia* (Fig. 6), and a long series of specimens would be required to show the immense range of individual variation by which all kinds of common appearances presented by dead leaves are reproduced. Among such variations is one in which the dark-brown ground-colour is almost uniform and unmottled inside the mid-rib-like stripe (Fig. 7). From this we pass to forms in which the stripe widens into a light band (Fig. 8), clearly showing its homology with the still more conspicuous band of *pelaspis* (compare Figs. 5 and 8). Such a variety as that shown in Fig. 8 is still a long way on the *archesia* side of a form intermediate between the wet and dry phase, and would certainly be cryptic rather than conspicuous in nature, although not so well concealed as the form shown in Fig. 7, and still less so than that shown in Fig. 6. Truly intermediate varieties between the wet and dry phases are not uncommon, in which

the broad band becomes sharply defined on its outer border, but lacks the light tint of the full wet phase.

These considerations and the careful comparison of Figs. 5 to 8 on Plate XIII will show the essential nature of the changes by which the cryptic under-side of the dry phase is converted into the startlingly conspicuous under-side of the wet phase, or *vice versâ*. The mid-rib-like stripe widens, lightens in tint, becomes sharply defined along its outer border, and is now the "warning band" of *pelasgis*. The row of ocellated spots, many of which, with semi-transparent white centres and specially-coloured borders, suggest holes in the apparent leaf of *archesia*, become entirely or almost entirely black upon the hind-wing, and gain intensely black borders upon the fore-wing of *pelasgis*, and, placed upon the light ground of the "warning band," render this feature still more conspicuous. The mottling disappears, and the ground-colour, both within and without the borders of the "warning band," becomes an almost uniform very dark brown, forming a most effective contrast with the band. Finally, the dead-leaf-like margin of the wing of *archesia* is rendered conspicuous in *pelasgis* by a black-and-white fringe and two parallel series of light markings just within and parallel to the much less deeply indented outline.

Furthermore, the comparison of Figs. 6 to 8 on Plate XIII with Fig. 5 on Plate XII shows clearly enough that the under-side of the dry phase of *archesia* differs from its upper-side in being cryptic, while the comparison of Fig. 5 on Plate XIII with Fig. 4 on Plate XII shows that the under-side differs from the upper-side of the wet phase (*pelasgis*) in being more conspicuous, thus in both respects acting like the two phases of *sesamius* and *antelope*. The under-side of *pelasgis* is more conspicuous than its upper-side because of the increased lightness and greater sharpness of the borders of the band and the greater contrast afforded by a darker ground-colour, also because of the more pronounced light marginal markings.

I have described the relationship between the phases of *archesia* at some length, because it was the consideration of this species which first convinced me of the validity of the interpretation here set forth, that we have convincing evidence of natural selection acting in two opposite directions in the two phases—in the one to produce the maximum of concealment, in the other a very efficient form of

conspicuousness. When I realized that it was the mid-rib-like stripe—the character which more than any other gives meaning to the cryptic resemblance to a dead leaf; that it was this very character which, transformed into the “warning band,” became the conspicuous feature of the wet phase—the operation of natural selection seemed as clear in the one case as the other.

When we examine the species of the whole genus *Precis* and those of the genera allied to it, the conclusion is forced upon us that the dry cryptic phases are ancestral as compared with the conspicuous wet phases. I do not mean to imply that the cryptic forms have not altered, but that the original form of the species possessed a cryptic under-side, which has been handed down with more or less change as the cryptic under-side of the existing dry phase, while the conspicuous under-side of the existing wet phase is a new and comparatively recent development. This question of the relative age of the two forms is most important and interesting, and from the very first occupied Mr. Marshall's attention. Thus the following passage is extracted from a letter written a few weeks after his discovery:—

“Salisbury, June 5, 1898.—I should be most interested to learn your ideas as to the reasons for the singular seasonal change in this species, for I must admit that I cannot arrive at any really satisfactory conclusion on the subject as yet. The blue scales of *sesamus* are my chief stumbling-block, for I certainly cannot perceive what utility they can possess, and considering its protective under-side colouring there seems no reason why it should not have retained its wet-season colours above, as in the case of *P. artaxia* or *P. ceryne*. I suppose you will agree that *sesamus* is a later development?”

For the reasons I have indicated above it is difficult to doubt that the cryptic character of the under-side of *sesamus* is ancestral and the conspicuous under-side of *natalensis* relatively recent, but with regard to the upper-sides this conclusion is by no means so evident. Indeed on comparing the species with *antelope* and other allies, it seems probable that the upper-side of *natalensis* is more ancestral than that of *sesamus*, having been chiefly modified in tint, thus falling into Müllerian association with the larger *Acraeas*. The upper-side of *sesamus* probably shows cryptic changes in the acquisition of the far darker

colours which render the phase less conspicuous in the stations it frequents.

There does not seem to be any escape however from the conclusion that the conspicuous under-sides of the wet phases are relatively recent, and if this conclusion be considered in relation to the comparison between the under-sides of *archesia* and *pelasgis*, it leads inevitably to the conclusion that the *conspicuous* appearance of the one *has* been modified out of the older cryptic appearance of the other, and not *vice versâ*.

On what hypothesis can we believe that such a change has taken place? In the existing state of our knowledge there are only two possible interpretations: (1) that the modification is mimetic of some other conspicuous distasteful form; (2) that it is a warning of some special protection possessed by the *Previs* itself. The former interpretation cannot apply to the case of *pelasgis*, because its pattern is so unlike that of the well-known distasteful Ethiopian Rhopalocera, although some advantage may be gained by Müllerian association with black and white aposematic genera such as *Amauris*, *Neptis*, *Planema*, etc. Furthermore, it has been shown that there are important elements in the conspicuous under-sides of the wet phases of *sesanus* and *antelope* which are not synaposematic, although the appearance as a whole is probably to be explained in this way. I therefore firmly believe that the conspicuous appearance of *pelasgis* has been produced by selection from the cryptic *archesia* as a warning character indicative of some special protection, an aposeme proclaiming that it is less palatable or in some way less suitable as the food of insect-eating animals than an immense number of other species which abound during the wet season in the same stations.

I proved in 1887 (Proc. Zool. Soc., p. 191) that the likes and dislikes of insect-eating animals are purely relative, and that a conspicuous distasteful form will be freely eaten under the stress of hunger, that the existence of these forms depended entirely upon the co-existence in their neighbourhood of an abundance of palatable species, that under any other circumstances the warning colours if freely exposed would be a danger and would lead to the extermination of the species. As soon as I had studied the case of *archesia* and *pelasgis* I felt convinced that the

extraordinary seasonal phases of *Precis* were to be interpreted along the lines suggested in 1887—that we have to do with a set of somewhat distasteful species which can only exist in the keen struggle of the dry African winter when food palatable to insect-eaters is relatively scarce, by a very high standard of protective disguise associated with the appropriate instincts, but gain the recognized advantages of aposematic colouring by producing markedly conspicuous generations during the moist summer, when insect-eating animals have a much greater variety and abundance of suitable food.

F. *The severity of the Struggle for Existence among Insects in the African Dry Season as compared with the Wet. The relation of the Seasonal Changes in Precis to those of other Butterflies.*

As soon as the idea expressed in the concluding paragraph of the last section of this memoir occurred to me, I wrote to Mr. Marshall asking for his experience on the subject, and also inquiring whether any of the admittedly unpalatable African butterflies exhibited seasonal changes, such that the winter generations became comparatively inconspicuous.

His deeply-interesting reply is printed *in extenso* below.

“Salisbury, Jan. 8, 1899.—As to your query about the keenness of the struggle for existence at the two seasons, in my own mind I had never felt any doubt that the dry season is certainly the more critical period for insects, and this I referred to incidentally in my paper on *Precis* (Ann. and Mag. Nat. Hist., ser. 7, vol. ii, July 1898, p. 36). It is true that insectivorous birds are far more numerous during the summer, but this I think would be more than outbalanced by the increase of such insects as Coleoptera, Hymenoptera, Diptera, etc., apart from the fact that the summer broods of the perennial butterflies are undoubtedly larger and much more numerous (some *Pierinae* have a fresh brood every four or five weeks), and that a number of additional species make their appearance at that season only. On the other hand, during the dry season, although a number of migratory birds depart northwards, yet we have a considerable number of resident insectivorous birds, including rollers, drongos, shrikes, flycatchers, bush-king-

fishers, etc., and owing to the warmth of the midday sun, even in mid-winter, the lizards are always more or less active, and the insectivorous mammals are probably in no way reduced. With the insects it is very different; owing to the parching up of the vegetation the hosts of phytophagous insects disappear almost entirely, and the diminution in insect-life is enormous, being most noticeable among the Coleoptera and least so among butterflies, of which latter almost two-thirds have winter broods; and moreover their lives would be rendered even more precarious by the generally adverse conditions of their environment from climatic causes. It therefore seems clear that the struggle for existence would fall pretty severely on butterflies during the winter, owing to their general conspicuousness, and that such is actually the case is shown by the numerous instances of the development of a highly-protective under-side coloration during the dry season among *Satyrinæ*, *Nymphaliniæ*, *Lycænidæ*, and *Pierinæ*. That the struggle is sufficiently keen, however, to compel unpalatable species to adopt protective coloration I should not like to say. The following is, I take it, a complete list of the South African genera possessing more or less undoubted distasteful qualities: *Limnas*, *Amauris*, *Acræa*, *Planema*, *Pardopsis*, *Neptis*, *Pentila*, *Alæna*, *Mylothris*, and *Pontia hellica*, and with the exception of *Acræa* none of these exhibit any change of colour during the winter which can possibly be construed as protective. Dealing therefore with *Acræa*, I find that even in this genus a considerable number of species such as *horta*, *neobule*, *anemosa*, *acara*, *enchedon*, *cabira*, etc., exhibit only a comparatively insignificant seasonal dimorphism or even none at all. There remains therefore a group composing such insects as *violarum-asema*, *nohara-halali*, *petræa*, *doubledayi-axina*, *atolmis*, *buxtoni*, etc., in which the dimorphism is fairly strongly marked in one sex or the other, and an interesting feature about this group is that they are all, with the exception of *petræa*, frequenters of open country, having a low flight and frequently sitting on the ground. It is also noticeable that this group, unlike the other, presents a very marked difference in the sexes, and wherever this is not the case, both sexes have a distinctly obscure coloration as compared with their congeners, *e.g.* *axina* and *asema*; further, that where the summer males exhibit any exceptional brilliancy, as *petræa*, *atolmis*, or

nohara, it is always compensated for by an exceptional dulness on the part of their respective females. I fear I do not feel sufficiently competent to attempt an explanation of the above facts, but I think you will agree that as a whole they hardly bear out the suggestion that distasteful species are compelled to adopt protective colouring in winter through the keener struggle for existence; and for the present I am tempted to incline to the view that the less marked cases of dimorphism may be attributable to purely climatic causes. The colouring of the other open veldt *Acrææ*, viz. *halali*, *axina*, and *asema*, is somewhat puzzling; for in the two latter it is far from being very brilliant or conspicuous; in *halali*, the male in summer is very brilliant, but the blackish or brownish grey of the female is certainly protective, and the insect when alarmed is very hard to follow with the eye in its low dodging flight over the herbage. In the winter the colouring of both sexes of all three species is certainly not very conspicuous among the withered grass. Either their unpalatability must be of a low order, or else they must be more subject to attack by some particular enemies than the woodland species. I should not be surprised if the rollers, of which we have five species, or cuckoos (also five) were to eat *Acræas*, as they are all far from particular as to their diet."

This hypothesis concerning certain of the smaller *Acræas* had been in Mr. Marshall's mind for a long time. Thus he wrote in 1896 from Natal:—

"*Estcourt, Oct. 15, 1896.*—I have an idea that all the species of the genus *Acræa* are not protected equally by nauseous taste, etc., and some of them perhaps not at all; for in many of the smaller species there is a marked seasonal dimorphism which has clearly a protective value. Now such a change seems hardly in keeping with warning coloration, which must be constant to impress itself on the minds of enemies, and moreover a species which requires protection by seasonal dimorphism cannot be very much protected in other ways, not to mention the fact that its colouring cannot be both warning and protective at the same time. There is, of course, nothing to show how much of the seasonal change we can attribute to climate alone. For instance, in comparing the slight alteration in an *A. acara* with the marked change in female *A. petræa*, are we to suppose that the dark-grey female of the latter

is due solely to climatic influence, and that such a change in the former is checked by the necessity for keeping the warning coloration uniform, or are we to consider that the slight change in the former is all that climate can effect, and that in the case of *petraea* this slight climatic effect has been enhanced by some other cause—presumably protection? Personally I incline to the latter view, but in either case it is clear that there are varying grades of protection by distastefulness in the genus.”

An extract from another letter states the same important conclusions as to the severity of the struggle during the dry season.

“*Salisbury, March, 10, 1898.*—There are very few butterflies (South African, at least), exclusive of the admittedly protected species and their mimics, of which the bright colour cannot be explained on the *Teracolus-Kallima* basis. The most evident exceptions are *Byblia*, certain species of *Precis*, as *sesamus* (form *natalensis*), *ceryne*, etc., which are practically coloured the same below as above, and *Belenois severina* and *mesentina*. The first I will admit has been so far a stumbling-block to me, though I am not yet prepared to accept it as a protected species. Provided that my ideas on seasonal variation in *Precis* be correct, these would also fall under the same heading as *Teracolus*, for like them they only assume the protective under-side colouring during winter, when attacks from birds are no doubt a great deal more to be feared, owing to the almost complete absence of *easily-caught* prey, such as beetles and other small insects; the summer forms probably are very little molested by birds, owing to their great agility and alertness, and the profusion of other insects at that period; they do, however, not unfrequently fall a prey to the rock-lizards, which stalk them with much astuteness, as I have observed on several occasions.

“With regard to *Belenois* my mind is still open, for it is a very curious genus, containing as it does the above two species which might perhaps from certain considerations be considered protected, and at the same time a species like *B. gidica* which evidently comes under the *Teracolus* heading, and lastly *B. thyse* which, to my mind at least, is clearly a Batesian mimic.”

After a consideration of the evidence brought forward above, it will be generally admitted that the struggle for

existence is far keener in the dry winter season, and that butterflies are especially subject to it.

The most distasteful forms, many of which are the models for mimicry, are sufficiently protected to retain their conspicuous aposematic appearance throughout the year, and either exhibit no change in the winter season or a change which is not in any way cryptic.

While this is true of all the larger and most conspicuous *Acræas*, some of the smaller *Acræas* do exhibit changes in a cryptic direction in their winter generations. These are *Acræas* which, from their colouring and habits, may be inferred to possess only a moderate degree of unpalatability as compared with the other species of the genus.

Cases in which colouring is "warning and protective [procryptic] at the same time" are quite common, *e. g.* the protected larvæ of many *Tenthredinidæ* which harmonize sufficiently well with their food-plant to be concealed at a little distance, but assume the most conspicuous aposematic attitudes and movements as soon as they are discovered and disturbed. But in the case of the smaller *Acræas* suggested by Mr. Marshall, the colouring which is most procryptic does not occur at the same time as that which is less procryptic or probably aposematic. Mr. Marshall's numerous experiments upon the edibility of the smaller *Acræas* (see Sections 9, 18, 19) do not support the view that any of them are palatable to the insect-eating animals made use of. It has already been pointed out that the refusal or evident dislike of insect food by captive animals is trustworthy evidence of unpalatability, while acceptance is not proof of palatability (see p. 317). The smaller *Acræas* furthermore fall into beautiful synaposematic groups (see pp. 492, 493); indeed a strong Müllerian association can be recognized throughout almost the whole of the Ethiopian representatives of the genus, as was first suggested by Professor Meldola (*Ann. and Mag. Nat. Hist.*, ser. 5, vol. x, 1882, p. 425).

It is therefore probable that these smaller *Acræas* are still specially protected, although to a less extent than other species of the genus, but that the keener struggle of the dry season has compelled them to produce generations which are inconspicuous as compared with those of the wet season.

If these interpretations here suggested be correct, the parallelism with *Previs sesamius*, etc., is very remarkable.

In the *Acræinæ* we find that the least unpalatable species of an unpalatable and conspicuous family have been compelled to produce relatively inconspicuous generations in the severe struggle of the dry season: in the *Nymphalinaæ* we find that some of the less palatable species of a comparatively palatable and inconspicuous family have been compelled to produce strongly conspicuous generations in the wet season when more edible insect food is abundant.

The interpretation I have here suggested was put forward very cautiously in a note, dated Nov. 1898, to a short paper on Mr. Marshall's results with *P. sesamius* in the Proc. Ent. Soc. Lond., Oct. 5, 1898, pp. xxv, xxvi. The note points out that insects with warning colours are not to be seen in an English winter. "Those such as *Coccinellidæ*, which exist in the perfect form, hide themselves. The reason probably is that the amount of palatable food available is not sufficient to make it safe to rely on unpalatability, accompanied by warning colouring [see also 'Colours of Animals,' London, 1890, pp. 179, 180]. Experiments with hungry animals support this view. It is possible that the conditions are similar in South Africa [it is perhaps unnecessary to state that *organic* conditions were alone referred to], and that warning colours are more characteristic of the wet than of the dry season, thus affording greater opportunities for mimetic resemblance. If it should hereafter be shown that *Precis* is to some extent unpalatable, and that its resemblance to an *Acræan* type is synaposematic rather than pseudaposematic, the parallelism with our own fauna would be even closer, the conspicuous species which hide and thus adopt procryptic habits being represented by one which gives rise to another brood with markedly procryptic colouring and habits."

Mr. Marshall in commenting on this note records the following interesting observations on the habits of South African Coleoptera as determined by damp and dryness.

"*Salisbury, Feb. 12, 1899.*—Do you think that the English *Coccinellidæ* really hide in winter owing to their increased danger from enemies, and not from climatic causes? I ask the question because in this country Coleoptera are highly susceptible to weather. They appear to be for the most part absolutely dependent on moisture, this being especially noticeable among the terrestrial forms such as *Cicindelidæ*, *Carabidæ*, *Psammodes*,

Anomalipus, etc. These insects appear with a rush as soon as the early rains have saturated the ground, but should a dry spell supervene, they disappear as rapidly as they came, only to emerge again on the recurrence of a good rain. The case of the dung-beetles has always puzzled me, for here we have a large family of powerful and apparently hardy beetles, which have a constant supply of food all the year round, and yet they are unable to stand out the winter in the imago state, although a delicate butterfly can do so. In fact, the *Copridæ* are quite as dependent on moisture as the large *Carabidæ*, and are only to be seen at work from November to March, retiring even then during the dry spells."

The interesting effects of dryness described above certainly cannot be produced in our damp winters, and it is difficult to believe that our cold can be the cause of the retirement of *Coccinellidæ*, etc., when species of insects closely allied to those of England can endure to be frozen stiff and brittle in a temperature of 50 degrees below zero (F.) in a Manitoban winter.

Another letter from Mr. Marshall, received about the same time, contains a different comment upon the interpretation suggested by the present writer in 1898 and here amplified.

"Salisbury, Jan. 8, 1899.—I can fully perceive that any arguments that may be brought forward in support of the contention that *Precis sesamus* (*natalensis* form) is an example of incipient mimicry are equally applicable to the suggestion of incipient warning coloration, and for the present it must remain a matter of opinion as to which is the correct explanation, though the alertness of the insect and its undoubted palatability, so far as lizards are concerned, seems to lend more support to the former view to my mind." [See also Ann. and Mag. Nat. Hist., ser. 7, vol. ii, July 1898, p. 35.]

It has been here shown that there are important elements in the under-side coloration of the wet phases of *Precis sesamus* and *P. antilope* which cannot be explained as mimicry, Batesian or Müllerian (see pp. 425–8), while the entire appearance of the under surface of *P. archesia* form *pelasgis* can only be interpreted as a warning character (pp. 428–431).

The conspicuous appearance of the under-sides of these forms is doubtless chiefly adapted to render them con-

spicuous during the attitude of rest. There is probably a certain parallelism with cryptic under-sides, such as those of our *Vanessidae*, which have no particular meaning in flight and when the insect alights, but still remains fully on the alert. The *resting attitude* is specialized in relation to the development of cryptic colours and patterns on the under-side, and in this attitude cryptic insects are always inconspicuous. Apart from the evidence of adaptation in the direction of conspicuousness on the under-side of the wet phases of *Precis*—the strongest argument for the presence of some distasteful quality—the mere existence of such an appearance in a palatable species is inconsistent with the explanation of cryptic under-sides as the product of adaptation in the direction of concealment from enemies.

The successful attacks of a species of lizard may be analogous to other well-known instances in which special enemies, such as the cuckoo, are known to devour conspicuous unpalatable insects.

Two other arguments in Mr. Marshall's paper (*Ann. and Mag. Nat. Hist.*, ser. 7, vol. ii, July 1898, p. 30) must be met here. First, the suggestion that the brilliant colours of *natalensis* are due to the impunity with which such a development can arise in the limited struggle for existence in the stations occupied by the species, and the abundance in the wet season of other insect food (*loc. cit.*, pp. 35, 36). Such a suggestion does not explain the under-side coloration, and especially the evidences of adaptation in it. Secondly, Mr. Marshall meets de Nicéville's and Weismann's contention, that both seasonal forms "must be adaptive, otherwise the non-adaptive form would be gradually supplanted by its more favoured relative," by the suggestion that the dry-season phase may be a recent development which is even now actually supplanting the wet phase (*loc. cit.*, pp. 36, 37). It is, however, difficult to believe, looking at the *Nymphalinae* as a whole, and especially the nearest allies of the species under discussion, that the conspicuous under-side of the wet phase is ancestral, and the cryptic under-side of the dry phase recent (see p. 430), so that the argument set forth above seems to me untouched. Mr. Marshall has indeed shown that the dry phase of *P. artaxia* has actually supplanted the wet phase (*nachtigalii*) in forest regions, where the struggle for existence is far more uniform at all seasons of the year than it is in the more open woodland country

in which the dry and wet phases alternate. The displacement of one form of *artaxia* by another is however no evidence of relative age, but only of relatively better adaptation to the conditions which obtain in the area where the displacement has occurred. Hence the observation recorded by Mr. Marshall seems to me strongly to confirm de Nicéville's and Weismann's conclusion that when both seasonal phases exist, both are adaptive.

Mr. Marshall also shows on pp. 421 to 423 that the species of *Precis* entirely restricted to forest regions possess cryptic under-sides and habits all the year round, although the dry-season generations are more completely cryptic.

It is not difficult to understand the observations referred to above,—viz. that the appearance and habits while cryptic all the year round should be more cryptic in the generations of greatest stress. Thus Mr. Marshall describes the wet-season phase of the purple-tipped South African *Teracoli* as having under-sides not specially well adapted for concealment on the ground during the resting attitude, and without the habit of suddenly settling when pursued, modes of concealment adopted by the dry-season generations. In such examples the success of the adaptations may be equal in the two seasons because of the difference in the intensity of the struggle. But the extreme seasonal phases of *Precis* can never be thus understood, because the wet forms are not merely less cryptic than the dry, they have gone over into the opposite camp, and have developed a very extreme, and, except in the examples of mimicry and warning colours, an unknown degree of conspicuousness.

Another and very interesting form of seasonal dimorphism is that which has been well known for a long time in the *Satyrinae*, and consists chiefly in the development of conspicuous ocelli, especially upon the under-side of the wet phases and their greater or less suppression in the dry. No interpretation of the change has, so far as I am aware, been attempted, except that of Portschinski, which has been further alluded to and criticized on p. 398. I think it is probable that a valid interpretation is suggested by the result of an experiment made in 1887, and witnessed by Professor Meldola as well as by me. A specimen of *Canonympha pamphilus* was introduced into a lizard's cage. "It was at once obvious that the lizard was greatly interested in the large eye-like mark on the under-side of the fore-wing: it examined the mark intently, and

several times attempted to seize the butterfly at this spot. The observation seems to point to, at any rate, one use of the eye-like markings which are common on the under-sides of the wings of butterflies," viz. in order to attract the attention of an enemy, and thus divert it from more vital parts ("Colours of Animals," London, 1890, pp. 206, 207). The same interpretation is suggested by the habits of many species which expose an eye-spot as soon as they settle, when they are likely to be seized by an enemy which has marked them down to their resting-place, but quickly lower the wings and conceal the spot, so that they are far more likely to be concealed from an enemy which has not been specially directed to the exact place by seeing them alight. (Much confirmation will be found on pp. 371-5, where Mr. Marshall's injured specimens are described.)

Such directive marks may well be an advantage in the wet season, when enemies with an abundance of other insect food are less keen in their pursuit of butterflies, but in the far greater stress of the dry season we can understand how they would become a danger, and how the only chance of the survival of the species lies in the adoption of a cryptic appearance, and cryptic instincts in their most extreme and unqualified form.

This explanation has much in common with that suggested for the seasonal phases of *Precis*. Indeed, it is of much interest to observe that *nachtigalii*, the wet form of *P. artaxia*, has precisely the same relationship to the dry form as that described above in *Satyrinae*. It is far less cryptic than the leaf-like dry phase, but it is not conspicuous. The ocelli on the under-sides of both wings and the strongly-marked hind margins, together with the specially prominent apex of the fore-wing, are probably directive characters which divert the attention of an enemy from the vital structures, when the insect is at rest with its wings closed.

The relationship of the interpretation in *Precis* to that just suggested in *Satyrinae*, and to that offered in certain smaller *Acræas* (see pp. 433-7), renders it on the whole improbable that there is any alternation in degrees of unpalatability corresponding to the alternation in the seasons. There is, however, no *à priori* difficulty in the hypothesis that a higher degree of unpalatability may be correlated with the conspicuous colouring of the wet phase of *Precis*;

and experiments specially undertaken in order to test the suggestion would be of much interest. That the hypothesis is improbable is further shown by a long series of experiments (hitherto only published in abstract in the Report of the British Association, Manchester, 1887, p. 763) which I conducted in 1887 with lizards and the highly insectivorous marmoset. Large numbers of the imagines of *Vanessa io* and *V. urticae* were made use of, and I came to the decided conclusion that both were somewhat unpalatable. They were certainly only eaten when the insect enemies under observation were hungry. Now the strongly cryptic under-side of both species associated with a fairly-conspicuous upper-side renders them in every way comparable to the dry phases of *Precis*. The results of my experiments suggest that if *Vanessa urticae* appeared on the wing in the teeming organic environment of Africa in the wet season—with far more enemies but an even greater preponderance of palatable insects—it would be to its advantage with its present degree of unpalatability to acquire a conspicuous under-side coloration, and thus to ensure easy recognition and rejection with comparatively little loss of life by experimental trials.

The considerations set forth above suggest what will probably hereafter be proved to be true, that a degree of unpalatability associated with a conspicuous appearance in the tropics will often appear associated with a cryptic appearance in the Holarctic Belt as well as in those areas of the tropics in which for special reasons the amount and variety of insect life is greatly restricted.

It is suggested on pages 475 to 477, that this is the interpretation of the loss of much of the aposematic appearance of *Limnas chrysippus*, var. *klugii*, on desert areas in the tropics.

To return to the seasonally dimorphic Ethiopian species of the genus *Precis*, if the two phases have been produced, as is here contended, by natural selection working in opposite directions because opposite kinds of adaptation are advantageous in the very different organic environments of the wet and dry seasons, the questions as to the way in which the change is actually determined, and as to the existence of any kind of susceptibility to external influences connected with the seasons, are still unanswered. The considerable amount of labour devoted by Mr. Marshall to the solution of this problem has up to the present

yielded negative results. Before describing his experiments and discussing the results, it is desirable to show the mode of succession of the phases in the wild state. By far the most complete evidence I have been able to obtain relates to a single species, *P. sesamus*.

G. *The succession of the two Seasonal Phases of* *Precis sesamus* *in Nature.*

The following extracts from Mr. Marshall's letters from 1897-1900 give an account of his experience of the succession of wet and dry forms of this species in the wild state, and also show how the conviction was gradually forced upon him that the early appearance of occasional specimens of the dry phase in the heart of the wet season is not due, as he thought at first, to exceptional climatic conditions (see also his paper in *Ann. and Mag. Nat. Hist.*, ser. 7, vol. viii, Nov. 1901, p. 402).

"*Malvern, Natal*; *March 12, 1897*.—You will notice that the dry forms of several species made their appearance at the Karkloof in the middle of February: this is most unusually early. I do not know whether it is a feature and characteristic of that locality or whether it is due to the abnormally dry weather during that month, which is usually one of the wettest in the year. The average rainfall for this February was considerably lower than it has been for twenty years. It is true that *here* the insects are still all of the true summer form, but the proximity of the sea may account for that."

"*Salisbury, March 6, 1898*.—*Sesamus* was unusually early here this year, appearing at the beginning of February, full six weeks before its usual time. This I am inclined to attribute to the exceptionally dry January and February we have had—normally our wettest months—though I am aware that Weismann considers that exceptional seasons have little or no effect on seasonal forms, which certainly does not accord with my experience in S. Africa."

"*Salisbury, Feb. 12, 1899*.—I send a specimen of *P. sesamus* ☉ captured on Jan. 27, 1899, on which day I also saw another. These two examples are of considerable interest as bearing on the problem concerning the stimulus which actually induces seasonal change in this species.

In a normal wet season (in which there are more or less continuous heavy rains from the middle of December to the end of February) *P. sesamus* ☉ appears at the end of March. Last season we had heavy rains up to the end of December 1897, but January was unusually dry and *sesamus* ☉ appeared on Feb. 6, being the earliest record I had for it. This season the drought was still more severe in January and commenced earlier, viz. about Dec. 12. This has been accompanied by a still earlier appearance of *sesamus* ☉. The evidence so far as it goes tends to show that climatic conditions, in some cases at least, are directly capable of inducing the change and upsetting the normal alternation of the forms. Here, owing to highly abnormal conditions, we have the dry form occurring at what is normally the very height of the wet season. Moreover, ever since I have observed seasonal dimorphism in butterflies I have noticed the effect of abnormal weather in retarding or accelerating the appearance of either form, and Barker has made similar observations at Malvern, near Durban, Natal."

"*Salisbury, April 25, 1899.*—The *sesamus* form is evidently more dominant than the *natalensis*, for despite the heavy rains in February 1899 the latter made very little headway after the appearance of the dry-season form; whereas among such insects as the *Pierinæ* the result of the alternating extremes was much more evident."

"*Salisbury, Feb. 7, 1900.*—In spite of our heavy rains during January (16·75 inches for the month) the winter forms of *Præcis* are appearing just as early as last year, which has puzzled me considerably. I shall send you the first examples of each form captured."

"*Salisbury, June 26, 1900.*—I am afraid I am not yet convinced as to the automatic alternations [viz. due to the organism itself and not to external stimuli] of the seasonal forms in *P. sesamus*; there seems to be at present an equal amount of evidence on either side, and until the matter can be settled by an exhaustive series of experiments I must retain an open mind on the question."

I have given below a list of all the specimens of the two phases of *Præcis sesamus* sent to me from Mashonaland by Mr. Marshall.

LOCALITY.	OBSERVER.	DATE.	FORM OF <i>Precis sesamus</i> IN HOPE COLLECTION.
Mazoe, 4000 ft.	G. A. K. Marshall.	Dec. 28, 1894.	1 <i>natalensis</i> , fresh.
Gadzima, 4200 ft., Umfuli River.	G. A. K. Marshall.	Dec. 20, 1895.	1 <i>natalensis</i> , fresh.
		Dec. 23, 1895.	3 <i>natalensis</i> , fresh.
Salisbury, 5000 ft. }	G. A. K. Marshall.	March 20, 1895.	1 <i>sesamus</i> , fresh.
		Feb. 13, 1898.	2 <i>natalensis</i> (in coitu). ♂ worn, ♀ fresh.
		Feb. 20, 1898.	1 <i>natalensis</i> , fresh.
		Feb. 27, 1898.	1 <i>natalensis</i> , worn (parent of 1 <i>sesamus</i> , and 1 <i>natalensis</i>).
		March 2, 1898.	1 <i>sesamus</i> , fresh.
		March 6, 1898.	1 <i>natalensis</i> , worn (parent of 1 <i>sesamus</i>).
		March 12, 1898.	1 <i>sesamus</i> , fresh.
		March 16, 1898.	1 <i>sesamus</i> , fresh.
		April 2, 1898.	1 <i>sesamus</i> , fresh.
		Jan. 27, 1899.	1 <i>sesamus</i> , fresh (the first seen in 1899).
		March 11, 1899.	1 <i>natalensis</i> , worn.
		Feb. 3, 1900.	1 <i>sesamus</i> , fresh (the second seen in 1900).
		Jan. 23, 1901.	1 <i>natalensis</i> , fresh.
		Jan. 26, 1901.	1 <i>sesamus</i> , fresh (the first seen in 1901).
		March 2, 1901.	1 <i>sesamus</i> , fresh, transitional towards <i>natalensis</i> .
		April 8, 1901.	2 <i>sesamus</i> , fresh.

A study of the above list makes it probable that the occurrence of occasional specimens of the dry phase of *sesamus* in January and February is a normal overlap.

Very careful and numerous records over a large number of years would be required to show that any change in the relative time limits of the two forms is taking place.

Owing to the kindness of Mr. S. L. Hinde, H. M. Sub-Commissioner, East African Protectorate, and Mrs. Hinde, I have received a most interesting series of the two forms from British East Africa, probably near the northern boundary of the range of the species. The numbers, captured in a short time on a limited area, are sufficient to enable us to judge of the relative proportions of the two forms, and we see that in May and the beginning of June the two occur mixed in about equal proportions, while in December and January the wet phase greatly predominates, although an occasional dry form appears, as it does in Mashonaland, early in January. I have included in the series two other specimens from near the northern part of the range of *P. sesamius*. The whole list is wonderfully similar to that from Mashonaland, and supports the view that Mr. Marshall's observations record the normal mode of replacement of the wet by the dry phase, although the former persists in large numbers much later in the north than it does in the south.

LOCALITY.	OBSERVER.	DATE.	FORM OF <i>Preis senarius</i> IN HOPE COLLECTION.	CHARACTER OF THE SEASON AT WHICH CAPTURE WAS EFFECTED.
N. Kikuyu Country, 5000 ft.	H. J. Mackinder and C. B. Hansburg.	Aug. 1899.	1 <i>senarius</i> , fresh.	The heart of the big dry season. Butterflies very scarce.
Near Mengo, Uganda.	Mrs. Leakey.	May 30, 1900.	1 <i>natalensis</i> , fresh.	
Machakos Road.	S. L. and H. Hinde.	May 22, 1900.	6 <i>natalensis</i> , mostly worn. 6 <i>senarius</i> , fresh.	The 12 insects captured in less than an hour on a patch of ground a few yards in extent.
Machakos.	S. L. and H. Hinde.	June 6, 1900.	2 <i>natalensis</i> . 1 variety nearer to <i>natalensis</i> . 3 <i>senarius</i> .	1 <i>natalensis</i> , is worn, all others fresh. The 6 insects captured together as above.
		Dec. 11, 1900.	4 <i>natalensis</i> , mostly worn.	As above, only well into the dry season. Two or three days heavy rain had intervened between this date and May 22. After the rains of the small wet season, and in the beginning of the small dry season.
Kitui.	{ S. L. and H. Hinde.	Jan. 2, 1901.	4 <i>natalensis</i> , mostly fresh. 1 <i>senarius</i> , fresh.	Nearly in the middle of the small dry season.
		Jan. 8, 1901.	1 <i>natalensis</i> , little worn.	Nearly in the middle of the small dry season.
		Jan. 12, 1901.	1 <i>natalensis</i> , fresh.	Nearly in the middle of the small dry season.

The succession of the seasons is very different, in the region in which Mr. and Mrs. Hinde captured the butterflies, from that which obtains in Salisbury. The two forms of succession are shown in parallel columns below.

BRITISH EAST AFRICA (MACHAKOS, KITUI, ETC.).		MASHONALAND (SALISBURY, MAZOE, GADZIMA).	
Mid-October to Mid-December	} Small wet season (about 17—18 inches).	Early November	} Wet season, average rainfall of Salisbury about 35 inches.
to Mid-March		to	
to end May	} Small dry season. Big wet season (about 17—18 inches).	Mid-April	} Dry season.
to Mid-October		to	
	} Big dry season.	Early November	

It is to be observed that the rainfall of the small and the big wet seasons are about the same, and also that the country is not really dried up in the small dry season except in unusually dry years. The country is always dried up in the big dry season.

In spite of these great differences in the seasons, the succession of the phases is wonderfully alike in the two areas, as has been pointed out above. We must conclude that *sesamius* can produce two seasonal phases annually but not more, so that the small dry season of the north is no more effective in producing the dry phase than the simultaneous wet season of the south. The species is so constituted that it produces a dry phase for the big dry season and a wet phase for the rest of the year, some of the dry-phase individuals being produced some months before the normal change takes place, viz. at and just before the beginning of the chief dry season. The difference between the date at which this great change of seasons takes place in north and south is attended by a corresponding difference in the date at which the wet phase of *sesamius* gives place to the dry. Both lists are unfortunately wanting at the transition from the big dry season to the wet. There is indeed only a single record for the period between the beginning of June and the beginning of December. Speaking from memory, Mr. Marshall thinks that the break from *sesamius* to *natalensis*

at the beginning of the wet season is not sharp; indeed, he has a distinct recollection of seeing them flying together at that season fairly frequently. "I believe," he writes (1902), "that in some seasons one might take *sesamus* in every month of the year. Certainly at Gadzima, in 1895, the true winter broods of *sesamus* lasted right up to the end of December. In a dry spring, that is when the rains are late in starting, butterfly life appears to be less abundant and the emergence of the wet-season forms seems to be retarded. On such occasions an actual break without specimens might occur in such a comparatively unfavourable locality as Salisbury. But I believe that this would be an unusual occurrence, and even if it happened in one locality I doubt if it would necessarily take place everywhere at the same time; for example, in the moister parts of the low veldt the succession of the broods would probably continue unbroken. I am quite satisfied that there are at least two or three broods of *sesamus* during the winter months, that is if the condition of wild specimens can be taken as any criterion. Food is much less plentiful in the winter, but it is obtainable in quite sufficient quantities to keep the species going. The change of seasons from wet to dry is of rather a gradual character; the reverse change is more marked, but this depends a good deal upon the total rainfall of the preceding year. When this has been heavy, the ground retains a certain amount of moisture throughout the winter, so that when the frosts cease and the sun's heat increases in the spring, a large number of the earlier plants spring up and flower before a drop of rain has fallen. But after a succession of dry years this does not take place, and, with possibly a few exceptions, none of the plants come out in response to the heat, but require the rains to bring them out. In this latter case the change in conditions is very strongly marked, much more so than during a wet cycle."

The discussion of the possible nature of the environmental stimulus, if any, is better deferred until after the description and consideration of Mr. Marshall's experiments in the next section.

H. *The attempt to control the Phases of P. sesamus and P. archesia by the artificial application of Moisture and Heat to the earlier stages. Suggested lines of Experiment.*

All the experiments hitherto made by Mr. Marshall were directed towards the production of the wet *natalensis* and *pelasgis* phases in place of the dry *sesamus* and *archesia* respectively. The whole of the specimens produced were presented by Mr. Marshall to the Hope Collection, and all are tabulated below, together with a statement of the experimental conditions which were employed in each case. All experiments were made at Salisbury.

The following extracts from Mr. Marshall's letters refer to some of the experiments on *sesamus*:—

"*Salisbury, June 5, 1898.*—I kept two larvæ in a damp jar, but one did not attach itself properly when pupating, and the resulting pupa fell down when soft and was killed. The other larva produced a black pupa which emerged as the wet form [April 13, 1898, in the Table below], but this was rendered nugatory by the fact that one of the larvæ in normal conditions produced the same form, though from a gilded pupa [April 20, 1898, in the Table below]."

"*Salisbury, April 25, 1899.*—I have fourteen bred specimens of *P. sesamus* which I will send later [specimens in year 1899 in the Table below]; I tried some experiments with them, but the results are mostly negative. There are two interesting varieties, one with a red bar in the discoidal cell and another with the red spots much reduced."

NUMBER OF EXPERIMENT.	DATES OF EARLIER STAGES.	SURFACE ON WHICH LARVA SUSPENDED (IF ANY).	COLOUR OF PUPA.	CONDITIONS OF HEAT AND MOISTURE.	DATE OF EMERGENCE.	PHASE OF <i>P. aestivata</i> .	WEIGHT ON JUNE 30, 1902.	SEX.
1	Larva suspended Feb. 19, pupated Feb. 21.	White paper.	Gilded.	Dry heat Feb. 21—28.	March 1, 1899.	1 <i>sestima</i> .	0.0722 grammes.	♂
2	Larva suspended Feb. 21, pupated Feb. 22.	Crimson paper.	Black.	Dry heat Feb. 22—March 1.	March 6, 1899.	1 <i>sestima</i> .	0.0722 grammes.	♂
3	Larva suspended Feb. 22, pupated Feb. 23.	White paper.	Gilded.	Dry heat Feb. 23—March 2.	March 6, 1899.	1 <i>sestima</i> .	0.0787 grammes.	♂
4	Larva suspended Feb. 24, pupated Feb. 24.	White paper.	Gilded.	Dry heat Feb. 24—March 2.	March 9, 1899.	1 <i>sestima</i> .	0.0422 grammes.	♂
5	Larva suspended Feb. 24, pupated Feb. 25.	White paper.	Gilded.	Dry heat Feb. 25—March 2.	March 10, 1899.	1 <i>sestima</i> (with red band on cell of fore-wing).	0.0722 grammes.	♂
	Larva suspended Feb. 24, pupated Feb. 25.	White paper.	Gilded.	Dry heat Feb. 25—March 2.	March 10, 1899.	1 <i>sestima</i> .	Not weighed; mended specimen.	♂
7	Larva suspended March 3, pupated March 4.	White paper.	Gilded.	Damp heat March 17, 7 p.m. to March 18, 2 p.m.	March 19, 1899.	1 <i>sestima</i> .	0.0772 grammes.	♂
8	Larva suspended March 9, pupated March 10.	White paper.	Gilded.	Damp heat March 17—21.	March 22, 1899.	1 <i>sestima</i> .	0.0772 grammes.	♂
9	Larva suspended March 11, pupated March 12.	Green stem in white box.	Gilded.	Damp heat March 17—21.	March 24, 1899.	1 <i>sestima</i> (red spots much reduced; bright blue shade of ground-colour).	0.0572 grammes.	♂
10	Pupated April 1.	—	—	Damp March 23.	April 13, 1899.	1 <i>sestima</i> (sestima damp in nature in middle of March).	0.0447 grammes.	♂
11	Egg laid March 6, hatched March 12, pupated April 7.	—	—	Damp March 30—April 5.	April 30, 1899.	1 <i>sestima</i> .	0.0717 grammes.	♂
12	Egg laid Feb. 27, hatched March 5, pupated March 31.	—	—	Normal.	April 15, 1898.	1 <i>sestima</i> .	0.0447 grammes.	♂
13	Egg laid Feb. 27, hatched March 5, pupated April 5.	—	—	Normal.	April 20, 1898.	1 <i>sestima</i> (but somewhat dark variety).	0.0722 grammes.	♂
14	Larva suspended Feb. 26, pupated Feb. 27.	Brown paper.	Black.	Normal.	March 13, 1899.	1 <i>sestima</i> (dark with small red spots).	0.0784 grammes.	♂
15	Larva suspended Feb. 27, pupated Feb. 28.	Brown paper.	Gilded.	Normal.	March 13, 1899.	1 <i>sestima</i> .	0.0752 grammes.	♂
16	Larva suspended Feb. 28, pupated March 1.	Brown paper.	Gilded.	Normal.	March 16, 1899.	1 <i>sestima</i> (largest red spots of all these imagines).	0.067 grammes.	♂
17	Larva suspended Feb. 28, pupated March 1.	Brown paper.	Gilded.	Normal.	March 15, 1899.	1 <i>sestima</i> (very dark with small red spots).	0.0697 grammes.	♂
18	Larva suspended March 3, pupated March 4.	White paper.	Gilded.	Normal.	March 19, 1899.	1 <i>sestima</i> .	0.0597 grammes.	♂

The experiments on the power of adaptation of the pupal colours to their environment are very interesting, and prove that the susceptibility resembles that of the allied British species *Vanessa urticae*. They also show that there is no essential difference between the colours of the pupæ of the two phases, but merely an adaptive response to environments which differ in colour at the two seasons, as suggested by Mr. Marshall (Ann. and Mag. Nat. Hist., July 1898, p. 33). It is clear, from the experiments, that if withered leaves of the usual winter yellow appeared, owing to exceptional circumstances, in the summer, larvæ suspended to them would produce gilded pupæ instead of the usual dark summer forms, and, *mutatis mutandis*, larvæ would produce dark pupæ upon dark leaves in the winter.

The highest form of procryptic defence, viz. the power of each individual to respond adaptively to any of its different normal environments, here exists in the helpless pupal stage, although the under-side of the wet phase of the imago can only be interpreted on the supposition that natural selection has developed a conspicuous appearance. Our own *Vanessidae* however offer examples of the same kind of association in the different stages of a single life history. Thus the pupæ of *V. urticae* and *V. io* have the same specialized power of concealment, while their gregarious black larvæ are excessively conspicuous and the imagines themselves by no means palatable to certain enemies of insects (see p. 442).

No special significance appears to attach to the varieties of the imagines produced in these experiments. The red bar in the cell of No. 5 is a common variety which indeed appears to be universal in the dry phase of the West African *P. octavia*, and red scales can be detected in this region in a large proportion of the individuals of *P. sesamus*. The red spots of No. 5 are not specially developed. The latter were largest in an individual exposed to normal conditions (No. 16), while Nos. 14 and 17, also exposed to normal conditions, were among the specimens with the smallest spots. The bright blue shade of the ground-colour of No. 9, exposed to damp heat, is well known in captured specimens from the most northern part of the range of the species as well as the south.

The specimens were weighed on an Oertling's balance, each pinned on a small cork foot which weighed .06275 grammes on June 29, 1902, and .00025 grammes more on

June 30. The weight of the No. 16 pin (D. F. Taylor's) was obtained by weighing three sets of ten similar pins. The weight of the first ten was .7960 grammes, of the second and third .7950 grammes. The average weight of a pin was therefore .07953 grammes, and this number added to .06275 was deducted from each of the specimens weighed on June 29 (see p. 456): added to .063 it was deducted from the specimens of the experiments recorded above, and all others weighed on June 30 (see pp. 451, 456). On the latter date the cork foot was weighed at the beginning of work, in the middle, and at the end. On all three occasions it weighed .063 grammes.

The consideration of the experiments on *Sesamus* is better deferred until after describing those upon *archesia*, although it is at once evident that no positive conclusions can be drawn as to the nature of the environmental stimulus. The negative character of the results obtained induced Mr. Marshall finally to form the opinion quoted below.

"*Salisbury, Feb. 26, 1902.*—I do quite agree with you now that in the case of *Precis* the evidence is sufficiently strong to show that climate has ceased to operate as the stimulus which calls forth the seasonal change. But I do not think that this view is applicable to other genera whose changes coincide closely with the changes in climate. The theoretical proposition I would suggest is that at its inception seasonal change was but slight and then due entirely to climatic action, such cases doubtless occurring at the present time. Any markedly useful variations of this kind would then be preserved and accentuated by natural selection, but climatic causes would still remain the controlling factor. Finally, as in *Precis*, the influence of natural selection would attain its maximum, and the seasonal changes would then take place solely as a result of this principle and irrespective of the influence of climate. It remains to be seen whether this can be proved by experiment."

On pp. 455 to 458 it will be seen that there are still hopes that the operation of some environmental stimulus may yet be discovered in the case of *Precis*.

The results obtained from the smaller series of experiments upon *P. archesia* are even more negative than those yielded by *P. sesamus*, as will be seen by a glance at the Table below, giving a complete account of all that has been as yet done.

DATES OF EARLIER STAGES.	CONDITIONS.	DATE OF EMERGENCE.	RESULT OF EXPERIMENT.
—	Normal.	April 20, 1899.	1 <i>archesia</i> .
Pupated March 23.	Normal.	April 14, 1899.	1 <i>archesia</i> .
Offspring of same parent <i>pelagis</i> .	Egg laid March 22, hatched March 27, pupated April 24.	May 7, 1899.	1 <i>pelagis</i> } <i>archesia</i> had replaced <i>pelagis</i> about beginning of April.
	Egg laid March 22, hatched March 28, pupated April 26.	May 14, 1899.	1 <i>pelagis</i> .
Pupated April 14.	Damp heat April 14—22.	April 28, 1899.	1 <i>archesia</i> .
Recorded in Ann. Mag. Nat. Hist., November 1901, p. 400.	Pupated April 17.	Damp April 16—May 6.	May 8, 1901. 1 <i>archesia</i> .
	Pupated April 30.	Damp April 28—May 17.	May 21, 1901. 1 <i>archesia</i> .
	Pupated May 6.	Damp May 5—May 28.	May 30, 1901. 1 <i>archesia</i> , var. <i>staudingeri</i> .

Concerning the specimens which emerged on May 7 and 14, and April 28, 1899, Mr. Marshall wrote as follows:—

“*Salisbury, Aug. 29, 1899.*—The case of *pelasgis* and *archesia* was very puzzling, as the results were just the opposite of what one would expect—the forced pupa emerging as the dry-form *archesia*, and the normal ones as the wet-form *pelasgis*, though this latter has disappeared for some time, being replaced by *archesia*.”

The negative results from these fairly-numerous experiments tempt us to believe that the change from *sesamus* to *natalensis* and *natalensis* to *sesamus* may be fixed in the constitution of the species, and may form an alternating series contemporaneous with the alternating seasons but not causally connected with them. Such a view is however rendered improbable, as Dr. Dixey has pointed out to me, because there would be nothing to prevent a gradual shifting and finally an entire want of parallelism between the two series. That, however, the change is essentially constitutional in the species and merely requires some external stimulus to set it going may be taken as certain. Furthermore, it is not necessary to suppose that a stimulus is required for *both* changes, the return to one of them, and presumably the more ancestral, may be in the nature of a rebound. The slight but distinct difference between the succession of the forms of *sesamus* in British East Africa and in Mashonaland also probably indicates a causal relation with the inorganic environment, and the same conclusion is supported by the fact that *artaxia* has been observed without its wet-season phase in a forest region (see pp. 422–3).

After Mr. Marshall's experiments it is difficult to believe that the application of heat or moisture or the two combined to the pupal stage can determine the production of *natalensis* or *pelasgis* in place of *sesamus* or *archesia*, respectively, at the period when the latter forms are becoming abundant in nature. It is possible that here we are merely witnessing the return to a more ancestral phase due to purely internal causes. The reverse experiment, viz. the application of cold, or dryness, or both combined, to pupæ of the earlier generations of *natalensis*, might produce more positive results and cause the appearance of *sesamus* at a time of the year when it is very rarely seen, although the occurrence of occasional individuals of *sesamus* in nature in the depth of the wet season seems to

be quite unrelated to dryness or cold (see pp. 443-8). But it would probably be necessary to apply artificial conditions to the larval stage. Indeed, the fact that the winter phases of certain species of *Precis* are so very much larger than the summer phases seems to require the conclusion that the change is pre-determined during or previously to the stage in which material is accumulated.

The differences in weight are well shown in captured individuals of two species in the following list: the method of procedure has been already described on pp. 452-3. It is seen that the dry phase always weighs more and sometimes over twice as much as the wet one.

SPECIES.	SEX.	LOCALITY.	DATE OF CAPTURE.	PHASE.	WEIGHT.
					FIRST 2 ON JUNE 29, REST ON JUNE 30, 1902.
<i>Precis antilope</i> .	♂	Salisbury.	March 2, 1898.	Wet.	·03422 grammes.
<i>Precis antilope</i> .	♀	Salisbury.	Feb. 27, 1898.	Wet.	·03747 grammes.
<i>Precis antilope</i> .	♀	Salisbury.	April 3, 1898.	Dry.	·07472 grammes.
<i>Precis antilope</i> .	♀	Salisbury.	March 9, 1898.	Dry.	·01947 grammes.
<i>Precis artaxia</i> .	♂	Umtali.	Dec. 27, 1900.	Wet.	·05597 grammes.
<i>Precis artaxia</i> .	♀	Umtali.	Dec. 30, 1900.	Dry.	·09672 grammes.
<i>Precis artaxia</i> .	♂	Umtali.	Dec. 30, 1900.	Dry.	·08447 grammes.
<i>Precis artaxia</i> .	♀	Gadzima, Umfuli R.	Dec. 29, 1895.	Wet.	·06622 grammes.
<i>Precis artaxia</i> .	♂	Gadzima, Umfuli R.	Dec. 30, 1895.	Wet.	·05422 grammes.
<i>Precis artaxia</i> .	♀	Gadzima, Umfuli R.	July 29, 1895.	Dry.	·06997 grammes.
<i>Precis artaxia</i> .	♀	Mazoe.	Dec. 28, 1894.	Wet.	·04522 grammes.
<i>Precis artaxia</i> (worn).	♀	Mazoe.	Oct. 23, 1894.	Dry.	·09547 grammes.

It may be argued that the results from captured specimens are untrustworthy because some females will have laid their eggs, some males will have paired, and others not. The five series of specimens of *sesamius* and *natalensis* bred by Mr. Marshall are not open to this objection and

are therefore of especial value. The weights of the eighteen bred specimens are given on p. 451, and it will be seen that the difference between the phases is very marked, although not nearly equal to that between the two forms of *artaxia*.

There is no escape from the conclusion that the larvæ of the dry phase of these species must be much larger than those of the wet, and must eat a great deal more food. This inevitable conclusion suggests that in experimenting on this most interesting of all known examples of seasonal change, it will be well to keep an open mind on all conceivable stimuli: on the abundance and character of the food-plant as well as the inorganic conditions of humidity and temperature, the latter of which has been proved by Dorfmeister, Weismann, Merrifield and Standfuss to be an effective stimulus in the case of certain Palearctic seasonally dimorphic species. It is possible that the parched state of the food-plant towards the end of the dry season may be the stimulus which determines development in the direction of the smaller summer phase. The different sizes and weights render it nearly certain, as I have argued above, that the phase is predetermined in the larval stage. Now the larval stage of the first dry-season brood is passed in the wet season, and that of the first wet-season brood probably in the dry. We must look to some condition affecting one or both of these larval stages, or the eggs from which they arose, as the stimulus which sets in motion the organic processes resulting in a change of phase. Some colour of support is lent to the suggestion that the condition of the food-plant may afford the necessary stimulus by the fact that the wet phase of *P. artaxia* is unknown in certain forest regions, where it is probable that the food is not subject to the same alternation of condition as in more exposed stations. But forests would also act as moderating influences for extreme differences in temperature and humidity, and thus tend to prevent these from acting as stimuli for the species in question; for we know that some stimuli must be effective in producing such seasonal changes as occur in other forest species of *Præcis* (see p. 423). Finally, quantity as contrasted with condition of food would be well worth trying. The unusually low weight of the imagines bred from the egg (Expts. 11, 12, and 13 on p. 451) was a probable result of difficulty in obtaining a constant supply of fresh

food in an entirely normal state, and it is noteworthy that one out of the three was *natalensis*. The extremely low weight of the ♀ *natalensis* in Expt. 10 also suggests some unfavourable condition in the larval state.

With the facts before us I do not see that any further suggestions can be made at the present moment; but I think the tables of weights clearly indicate the period at which the stimuli should be applied, while temperature, humidity, quantity or quality of food, or some combination of these, seem to exhaust all probable influences in the direction of a change of phase.

I. *The Bearing of the Seasonal Phases of Precis upon the Science of Insect Systematics.*

The results which have been described and illustrated in this section of the present memoir are so startling that they may well shake the confidence of naturalists in the whole fabric of insect systematics. If such forms as *natalensis* and *sesamus*, as *simia* and *antelope*, as *pelasgis* and *archesia*, are nothing but the generations of two alternating phases of a single species, approximately synchronized with the heat and cold or humidity and dryness of the alternating seasons, naturalists may feel driven to ask, "What becomes of the validity of specific distinctions?" Between the two phases of *Precis sesamus* there are extraordinary differences in colours, pattern, shape of wings, relation of upper- to under-side, nay, even in instinctive habits, including the choice of particular stations. This latter distinction between the phases is but the outward expression of some profound difference in the intimate structure of ganglionic centres and intercommunicating strands in the central nervous system. Important differences in venation are incidentally brought about by the great differences in the shape of the wing. The extreme rarity of intermediate varieties furthermore recalls the abrupt transitions which are so common, although very far from universal, between species of animals which are assumed to be distinct. Under the shock of Mr. Marshall's discovery that *sesamus* and *natalensis* are two forms of the same species, the systematist may well feel doubts about the foundations upon which his science has been erected. In these distracting circumstances a firm belief in natural selection will be found to

exercise a wonderfully calming and steady influence. The structures which are adopted as the conventional criteria of specific distinction are of course modified by natural selection and brought into adjustment with new conditions of the struggle for existence as one species is gradually changed into another; but they are also capable of modification in one and the same species as it passes through various conditions during its life-history and in sexual and other dimorphism. The species frequently requires that the female sex should be more protected than the male, and hence we often witness a more perfectly cryptic appearance and habits in the female, and mimicry in the female alone. In many kinds of di-, tri- and polymorphism we see a species more perfectly protected at one and the same time by extending the area over which it must be sought by its enemies—in cryptic resemblance, earth and bark as well as leaves and shoots—in mimetic resemblance, Danaine or other distasteful models not of one species alone but two or more. In the di-, tri- or polymorphism of the social Hymenoptera and Neuroptera we see the specialization of the individual for the good of the community. In the extreme cases of seasonal dimorphism, exhibited by the genus *Precis*, there is a far less common modification of a species into two series of generations respectively adjusted to the conditions obtaining at two seasons of the year. But less marked cases of the same kind are probably not uncommon. There is however nothing revolutionary or subversive in any of these interesting facts. The conventional marks of specific distinction remain just as they were, convenient indications to the systematist, enabling him provisionally to separate groups of individuals into the assemblages we call species. When his work is done carefully subsequent breeding experiments will, we may be sure, confirm his conclusions in the majority of cases. But here and there startling exceptions will be found when it is to the advantage of a species to appear in two or more very different forms. In such cases the reason for the difference can generally be satisfactorily explained on the principles of natural selection; and when such an explanation is possible or even probable it is quite unnecessary to assume that the exceptions possess a numerical importance sufficient to shake the foundations of systematics.

Certain species are cryptic while others are aposematic

or pseudaposematic; certain stages in the life of an individual may be cryptic, others aposematic or pseudaposematic. There is nothing subversive in the thought that certain species exposed to different organic environments in two seasons of the year may appear as cryptic generations at one of these, aposematic or pseudaposematic at the other. The explanation is at any rate sufficiently probable to enable us to contemplate Mr. Marshall's wonderful discovery with equanimity and with an interest undisturbed by the thought that he has laid in ruins the whole edifice of insect systematics.

29. THE GREGARIOUS INSTINCT IN HYBERNATION AND EMIGRATION OF INSECTS. (E. B. P.)

The interesting observation that individuals of *Precis sesamius* are apt occasionally to congregate in large numbers as they go to roost, led me to reflect on the possible meaning of such an instinct. Mr. Marshall records other examples of the same kind "in species of *Euralia*, also in *Belenois*, *Herpænia criphia*, and *Teracolus eris*" (Ann. and Mag. Nat. Hist., *loc. cit.*, 1898, p. 34). It is possible that one interpretation does not explain all these cases, but I think it is probable that the observed instances of the congregating of *Precis* and *Euralia* are sporadic examples of an instinct which is associated with hybernation or, at any rate, a prolonged period of rest during a time of relatively excessive cold, heat, or dryness. Objection may be taken to this interpretation on the ground that large companies undergoing a prolonged rest ought to be well known in these species. It is possible however that the extreme conditions which render such a state desirable or even necessary for the species are not common, and, when they occur, do not conduce towards the active pursuit of natural history; furthermore, such prolonged rest would probably be passed through in some hidden recess which could only be found by accident.

Large numbers of naturalists for hundreds of years have been interested in the doings of *Vanessa io*, but, so far as I am aware, it is not generally known that this species may display a gregarious habit in hybernation.* My friend,

* Edward Newman recorded the occurrence of a company of more than forty *V. io* in a hollow oak (British Butterflies and Moths, London, N.D., p. 16), and the Rev. Joseph Greene disturbed three

Dr. W. Hatchett Jackson, the Radcliffe Librarian at Oxford, permits me to publish the following observation made by him at Weston-super-Mare in the second week of January 1895. Dr. Jackson found, in the garden of his house, on the side of a hill sloping south, about twenty peacock butterflies hibernating in the heart of a bramble-bush. The butterflies were arranged in rows on two or three approximately horizontal runners about a foot from the ground. All rested with their wings hanging downwards. When the butterflies were first disturbed they made no movement, but on repeated disturbance they

specimens in the hollow formed by the arching roots of a large beech-tree, in Dec. 1852 (G. C. Barrett, British Lepidoptera, London, 1893, vol. i, p. 139). W. S. Coleman (British Butterflies, London, 1862, p. 88) quotes Doubleday in the *Zoologist*:—"Last winter some large stacks of beech faggots, which had been loosely stacked up in our forest (*Epping*) the preceding spring, with the dead leaves adhering to them, were taken down and carted away, and among these were many scores of *io*, *urticae*, and *polychloros*." No reference is given, and I have failed to find the original statement. An observation of Mr. Banning of Monte Video, Ballacrairie, Isle of Man (also quoted by Coleman, l. c. p. 91), is recorded in the *Zoologist* (1856, p. 5000):—"Whilst standing in my farmyard on the day following Christmas Day [1855], it being unusually fine and warm, I was suddenly astonished by the fall of more than a hundred of the accompanying butterflies [*Vanessa urticae*]. I commenced at once collecting them, and succeeded in securing more than sixty. . . ." This observation apparently points to the emergence of a hibernating assemblage in consequence of exceptionally warm weather. It also indicates conditions which at a normal time of the year would be favourable to pairing.

Mr. J. W. Tutt states that the imagines of *V. io* feed largely during August, disappearing at the end of the month or in September (Entomologist's Record, 1895-6, vol. vii, p. 3). It is therefore probable that the butterflies produced by one company of larvæ do not keep together, or the fact would certainly have been noticed when they are in search of food. It is probable that the products of all companies scatter and become thoroughly intermingled before again assembling into groups for hibernation. Another line of evidence may perhaps yield incontrovertible proof of the existence of this intermixture before reassembling—a probable adaptation to prevent in-and-in breeding. Dr. W. H. Jackson and Mr. O. H. Latter, F.E.S., have found that the pupæ obtained from different batches of larvæ of *V. io* "were principally, but not entirely, of one or of the other sex" (Trans. Linn. Soc., London, vol. v, 1890, p. 156). It would not be difficult to obtain a numerical statement of the average constitution of a company in this respect, so that it would be available for comparison with that of a hibernating group. A marked difference would prove intermixture before hibernation, while a similar constitution would yield negative evidence.

flicked their wings and the movement passed along the row. It must be remembered that the climate of Weston is extremely mild, and the great frost of 1895 had not then begun.

The advantages of a period of rest during excessive heat and dryness may be as great as those which follow from excessive cold. In the former the food-plant may be parched and dry or confined to very few and widely-scattered damp spots, and the perfect insect may pass through its life without the chance of laying eggs in places where the larvæ would be able to survive. But quite apart from this, the continuous excessive drought may be injurious to the perfect insect itself. At the driest and hottest part of the African dry season a great scarcity even of common butterflies has been noticed, and it is not unlikely that many individuals of some species pass through the most critical period of very dry and hot years concealed in a state of rest. It is significant that the congregating instinct has only been observed in the dry phase of *Precis sesamus*.

This does not solve the problem of the gregarious instinct itself. It is clear that Dr. Jackson's observation on *V. io* and Mr. Marshall's on *Precis*, etc., indicate the existence of an instinct which must be a real and great danger to the species. The less the individuals congregated and the more widely they scattered, the greater would be their chance of safety. A fortunate enemy finding one of the peacocks in the bramble-bush at Weston would have secured the whole. It is therefore certain on the principles of natural selection that some great advantage is gained by the instinct, an advantage which more than compensates for the increased danger. I would suggest that this advantage is the facility given for pairing and the laying of eggs without any loss of time, as soon as the period of rest comes to an end. The advantage would be quite as great or even greater after the rest during drought than after ordinary hybernation, because of the rapidity with which the food-plant recovers with the first moisture. It would be interesting to consider from this point of view the food-plants of the African species in which the instinct has been observed.

This suggestion naturally leads to a consideration of the gregarious instinct in the peculiar form of emigration which has been observed in insects. The same increased

dangers attend the phenomenon, and I think it is very probable that they are more than compensated by the analogous benefits. The instinct to emigrate probably exists in a dormant state in all species liable from their powers of rapid multiplication suddenly to outrun the food-supply in any part of their range. The stimulus which evokes the instinct is, in such insects as the locust, or such mammals as the lemming, probably merely the direct and obvious incentive of hunger (A. R. Wallace, "Geographical Distribution," London, 1876, vol. i, p. 18). In the majority of perfect insects, however, we cannot accept this interpretation, and we are compelled to look for a stimulus in some other result of undue increase—the crowds of individuals everywhere, the food-plant covered with eggs and young larvæ, and females laying still more eggs. Then probably arises the imperative instinct to move, perhaps in both sexes, perhaps only in the female, the males accompanying them (in many species in far larger numbers). And the instinct further compels the individuals to move together in vast masses in the same direction, rather than to scatter and fly in all directions. The increased danger from enemies is of course lessened, as compared with the hybernating companies, by the enormous number of emigrating individuals; but there is, I believe, the solid advantage that fresh food-plant may be found in another uncrowded area; that the limits of the normal range of the species may be overpassed; that areas from which the species has been driven may be regained:—not by single individuals or by a very few pairs, but by immense numbers of both sexes without any of the dangers of in-and-in breeding when once they have established themselves as a fresh colony. In this way the range of many species has probably been extended in the past, and, although the emigrating crowds so often described may again and again be landed in a foodless desert or the sea, the instinct is advantageous in that it utilizes individuals which are at the moment useless and even injurious to their kind, in a manner which may be in a high degree beneficial (see also Trimen, "South African Butterflies," vol i, 1887, p. 31). The suggestion is made that the crowded masses, resulting from over-production and inability of enemies to cope with the increase, are injurious to the species, because it is likely that food-plants would be checked for years or even killed

out altogether in certain localities, while the heaps of dead individuals would encourage the attack and rapid spread of bacterial foes. Indeed, the advantages to be derived from the removal of the surplus from an overcrowded area may probably outweigh those which accrue from the occasional successes in colonization, and may more than the latter account for the development by natural selection of the instinct to move. The massing of the moving individuals and their flight in the same direction seem, on the other hand, to have arisen by selection from the beneficial results conferred by spreading into less crowded areas. It is difficult to imagine any other possible means by which such animals as insects could overcome the effects of a sudden increase too great for the restraining influences of their natural enemies—effects which insufficiently checked for a few generations would inevitably lead to the destruction of the species in the area of overproduction.

We may well inquire why it should be necessary for such emigration, with a possible successful issue in colonization, to require the services of countless individuals when the importation of half-a-dozen rabbits or a few specimens of *Pieris rapæ* will, for the naturalist, change the face of a continent. The results of these unintentional, or intentional but ill-considered, experiments do indeed shake the belief in the paramount necessity for crosses and the dangers of in-and-in breeding; but the end is not yet, and the teeming colonies which have arisen from such small beginnings may in time vanish from the operation of deep-seated causes. The varied adaptations for cross-fertilization and the prevention of in-and-in breeding are so evident in nature, that we are compelled to believe that they meet and counteract serious dangers which sooner or later would menace the very existence of the species. And among other adaptations it is significant that the instinct under discussion should lead to the streaming of large populations, and not of small batches of individuals from an area of high pressure.

The gregarious instinct in emigration has been observed in many groups of insects beside the Lepidoptera. I need only mention here the hundreds of *Ammophila hirsuta*, ordinarily a solitary species, found by Fabre under a large flat stone on the summit of Mont Ventoux at a height of 6000 ft., and the crowds of ladybirds witnessed by him

on the same mountain and on the tableland of St. Armand ("Insect Life," English translation, London, 1901, p. 193). A valuable account of a large number of observations will be found in Mr. J. W. Tutt's numerous papers on "The Migration and Dispersal of Insects" (Ent. Record, 1898-1902). The author recognizes the dangers of over-multiplication as a cause of migration (l. c. vol. xii, 1900, p. 238: see also vol. xiii, 1901, p. 200). Numerous examples quoted by him prove that movement in vast bands, often at great distances from land, has been observed again and again in those very species which are remarkable for their wide geographical distribution and occurrence upon oceanic islands. The appearance of two species of *Hybernina*, *H. defoliaria* and *H. aurantiaria*, observed in large numbers in Heligoland by Gütke, cannot be explained on the hypothesis here suggested because, the females being flightless, males only appeared. In several other instances recorded by Mr. Tutt the presence of both sexes is either specially affirmed or implied. In the great majority of cases, however, no observations of sex were made, and it is to be hoped that careful attention may be paid to this point in the future. The proportion of females to males would also be deserving of careful investigation.

The limits of this memoir are perhaps too wide already, and it is impossible to attempt any discussion of these observations in detail, but I have taken the opportunity of making a suggestion as to the possible essential meaning of the instinct.

I have deliberately used the word "*emigration*" of insects, because this term probably expresses the exact state of the case. In response to some stimulus connected with undue increase, immense masses of individuals *move out of* an overcrowded area. The line of movement may carry them to destruction or to plenty, in both cases benefits are probably gained, although they are of course much greater in the latter. True "*migration*" as of birds and perhaps of fishes implies different and far higher faculties—the memory of the individual summed up by tradition into what may be called the collective memory of the species.

30. DESCRIPTION AND DISCUSSION OF MATERIAL BEARING ON MIMICRY IN SOUTH AFRICAN RHOPALOCERA COLLECTED BY GUY A. K. MARSHALL, AND THE RECORD OF OBSERVATIONS MADE BY HIM. (E. B. P.)

The splendid material which is described and discussed below has gradually accumulated as the result of Mr. Marshall's kind and generous response to my desire for specimens for the Hope Department illustrating the fact that mimetic species and their models, and the members of large convergent or synaposematic groups, not only inhabit the same areas but fly together at the same time. The study of this material naturally led to conclusions and suggestions which it is hoped possess a general interest in relation to the doctrine of evolution and the important part which mimicry plays in it, as one of the chief evidences of the operation of natural selection. These more general discussions are placed under separate headings immediately after the groups whose study gave rise to them.

The last sub-section is placed under Mr. Marshall's name, being quoted *in extenso* from his letters.

A. *Black-and-White Amauris-like Group.*

The central model for the group described below is probably *Amauris ochlea*, but it was not captured on March 27, 1897, when five convergent individuals were taken at Malvern, near Durban, Natal. The group as captured is as follows:—

Planema aganice ♂.

„ *esebria* ♀, var. with white markings.

Neptis agatha ♂.

2 *Nyctemera leuconoë*.

The male *Planema aganice* is but an imperfect member of the group, the lighter markings being buff instead of white, as in the female. We thus find that the latter sex forms closer synaposematic resemblances than the male, when the two sexes differ. It is probable that this relationship between male and female will be found to be generally true of Müllerian mimics in which the sexes exhibit different degrees of likeness to the type of some group characterized by Common Warning Colours. Furthermore, the culmination is often reached in Müllerian

mimicry, just as it is in Batesian where it has long been recognized, in species of which the female enters into a more or less well-marked membership of a group towards which the male has made no apparent approximation. Numerous examples will be found in the present memoir.

This interesting similarity between Müllerian and Batesian mimicry was probably unrecognized until 1894, when it was discovered by F. A. Dixey,* because of the fact that in the first-known examples of Müllerian mimicry in tropical America, which are the most wonderful instances in the world, the convergent pairs and groups contributed by the *Heliconinae* and *Ithomiinae* and by different genera within each of these sub-families, are made up of species with males and females which are superficially alike.

Now, however, that the principle has been recognized by Dixey in many Neotropical Müllerian mimics with differing sexes and here in many Ethiopian, the explanation is doubtless the same as that suggested by Wallace (Trans. Linn. Soc. xxv, Pt. I, 1865) in the case of Batesian mimics, viz. the great importance for the species that the female, with her slower flight and the necessity to pause and lay her eggs, should gain to the full the advantages of that extra advertisement of warning coloration which is conferred by membership in a synaposematic group. This is the interpretation offered by Dixey in his 1894 memoir (q. v.).

Neptis agatha exhibits in an interesting manner that concentration of white markings into four large patches, one upon each wing (save that the fore-wing is invaded by a small portion of the hind-wing patch), and that disappearance of the other bars and markings, except for traces on the under-side, which are characteristic of many Ethiopian species of this genus, and doubtless indicate a synaposematic approach to the black-and-white species of *Amauris* and *Planema* of the Region.

It is too wide a subject to introduce into the present memoir, but I cannot forbear to allude to the evident synaposematic sensitiveness of the genus *Neptis*, leading it to form associations with local conspicuous Rhopalocera. Among the most beautiful of these are *N. venilia* and *N. lactaria*, which resemble the remarkable Danaine genus *Hamadryas*, especially upon the under-side. Again, the

* Trans. Ent. Soc. Lond., 1894, p. 298, note; 1896, pp. 70, 71; 1897, pp. 319, 326-328, 330.

likeness to *Athyma* and *Limenitis* must have struck every naturalist who has looked through the drawers of a tolerably large collection. Col. Swinhoe has recently called my attention to a *Euplœa*-like *Neptis* from China, *N. imitans*.

The resemblance of the genus *Neptidopsis* to *Neptis* seems, on the other hand, to have been due to mimetic approach on the part of the former towards the type set by the latter.

The Hypsid moth *Nyctemera leuconoë* seems to have independently adopted the same aposematic scheme of colouring as the genus *Amauris*, the only change in the direction of the latter dominant type being a slight broadening of the white bar crossing the fore-wings, a broadening which is at once recognizable when this and other African species of the moth are compared with their nearest Oriental allies. The conspicuous and almost certainly specially-protected *Hypsidæ* strongly tend to enter into synaposematic association with other specially-defended forms in various parts of the world. Thus one species approximates towards *Hamadryas*, while, in tropical America, the smaller forms become transparent and resemble the smaller *Ithomiinæ*, while the larger (*Pericopsis*) possess the warning coloration of species of *Melinæa* and *Heliconius*.

B. *Limnas chrysippus*-like Groups.

The first of these groups was captured on March 6, 1897, at Malvern, Natal. It consists of the eight following individuals:—

Limnas chrysippus ♂.

" " ♀, var. *alcippoides*.

Hypolimnas misippus ♀, with pale hind-wings like the last-named insect.

H. misippus ♀, var. *inaria*.

Planema esebria ♀, *chrysippus*-like type-form with white sub-apical bar to fore-wings and reddish-brown black-bordered hind-wings, the ground-colour extending on to the fore-wings.

Acræa encedon ♂.

A. serena, var. *buxtoni*, ♀.

A. doubledayi ♂.

The latter individual, being a male, is not really a member of the group, inasmuch as it lacks the oblique

sub-apical white bar present in the female of typical *doubledayi*. The presence of the male indicates, however, that the female flies with the other members of this *chrysippus*-like group, of which it forms an imperfect and outlying constituent. The male of *serena* also does not resemble *chrysippus*, while the female is an even more imperfect Müllerian mimic than the female of *doubledayi*. Nevertheless such cases are of the highest interest, inasmuch as they enable us to understand how mimicry arose in species which now exhibit a startling likeness. *A. encedon*, one of the most perfect Müllerian mimics of *chrysippus*, presents an equally close approximation in male and female.

The fact that the female of *P. esebria* should present two well-marked varieties, one of which falls into a black-and-white group convergent round the species *Amauris*, while the other, the type-form, enters the combination which surrounds *L. chrysippus*, recalls a principle already well known and probably correctly understood in the case of Batesian mimicry. When an abundant well-protected *Acraea* thus approximates to two very different Danaine patterns it is obvious that we are not necessarily driven to a Batesian interpretation of the forms of the female *Papilio cenea*, which approximate to the appearance of *Amauris echeria* as well as to the two other Danaine types alluded to above. The enemies of *chrysippus* and the species of *Amauris* are certainly not precisely the same, and it may well be an advantage to a Müllerian mimic to secure that increased protection from insect-eating enemies which is conferred by belonging to two or more groups.

Furthermore, the *Planema* has come to resemble the Danaine and not the Danaines the *Planema*, and this probably indicates that the Danaine is on the whole the less attacked and the better known. It is probably of advantage to the whole group that the Danaine which set the pattern should still be the dominant member of the assemblage of which it is the centre. This dominance is favoured by the individuals of an abundant species joining two or more groups instead of throwing the whole of their number into a single one. In the case of Batesian mimicry, where the mimics are comparatively palatable and would be freely eaten if recognized, the advantage of this di- or trimorphism and the likeness to two or three models is even more obvious.

A second group of the same type was captured in the same locality on March 30, 1897, and consists of six individuals:—

L. chrysippus ♀.

H. misippus ♀, a pale patch in the centre of each hind-wing.

P. esebria ♂, buff sub-apical bar to fore-wing.

A. encedon ♂.

A. serena, var. *buxtoni* ♀.

A. petræa ♀.

The lack of correspondence between the varieties of the females of *H. misippus* and those of the central member of the group is well seen in these two sets. Thus one of the three females is the *inaria* form, although the *klugii* var. of *chrysippus* is almost unknown in S. Africa, while the other two suggest the appearance of the *alcippoides* var., which does indeed occur not uncommonly, but is not nearly so abundant as typical *chrysippus*. The female of *A. petræa* is another outlying member of the group, while the male is altogether outside it.

A third group, captured by Mr. Marshall at Salisbury on April 10, 1898, contains these species:—

L. chrysippus ♀ }
H. misippus ♀ } all typical forms.
 2 *A. encedon* ♂ }

A fourth group captured at the same locality on April 9, 1899, contains:—

2 *L. chrysippus* ♂, ♀ (Plate XIV, figs. 1, 1*a*).

2 *Mimacræa marshalli* ♂ (Plate XIV, figs. 2, 2*a*).

This beautiful Lycaenid mimic presents in some respects a closer approximation to *Acræa encedon* (Plate XIV, figs. 3, 3*a*) than to *L. chrysippus*, the primary model of both. Thus the character and contour of the sub-apical white bar of the fore-wing suggests that of the *Acræa* rather than the *Danaine*. In the two former the bar is more continuous, in the latter more obviously broken into discontinuous spots, attended by outlying smaller spots. Another far more important similarity between Lycaenid and *Acræa* is brought about by the numerous conspicuous black spots which in both are scattered over the basal part of the under-side of the hind-wing. In other respects the

under-side of the Lycænid presents a much closer approximation to the Danaine than does the Acræa. In well-marked individuals there are fourteen of these spots in the Lycænid, nineteen in the Acræa. In place of these, the Danaine model possesses, in addition to the marginal white-marked spots and a single spot at the extreme base of the wing, only a row of three spots on the outer boundary of the cell in the female, with an additional white-centred black patch, marking the scent-pouch, in the male. The three spots along the outer margin of the cell are encircled with white, as are all the spots in the Lycænid; while the veins of the under-side of the hind-wing in both are more or less emphasized with white. In these minor but distinct points the Lycænid approximates to the Danaine and not to the Acræa; and furthermore in the fact that the black spots of the under-side of the hind-wing are hardly visible on the upper-side of the Lycænid, while all except the basal ones are as distinct upon the upper- as upon the under-side of the Acræa. In the Danaine they are very distinct although much smaller on the upper-side, but as there are only three in the female and four in the male, the Acræa is in this respect much further from the other two than they are from each other, its distance being still further increased by a few (4—6) large conspicuous black spots on the ground-colour of the basal half of both surfaces of the upper wing. It is noteworthy that these points of divergence on the part of *A. enceldon* are characters which it shares with a large number of related species. All the points mentioned above can be well seen in the six upper figures of Plate XIV, which should be compared with the six corresponding figures on Plate XV, showing the prevalent form of the Danaine model and its Acræine and Lycænid mimics much further north in British East Africa.

In the dark shade of the brown ground-colour the Acræa is much nearer to the Danaine as developed in S. Africa than the Lycænid, and upon the wing the black spots would probably make the Acræa appear still darker. The bright fulvous tint of *M. marshalli* is more of the shade of the Oriental specimens of *chrysippus*. This relationship appears to exist between many of the other African Müllerian and Batesian mimics of *L. chrysippus* and their model, and suggests that the Oriental bright shade is ancestral, although the Oriental intrusion is comparatively

modern, as proved by the relatively small amount of mimicry, and that little very imperfect, in species peculiar to the Region. The fact that the bright Oriental shade still persists in many of the specimens of *chrysippus* from the north-east and probably other parts of Africa, supports the same conclusion.

Mr. Roland Trimen points out that the *Mimacræa* also resembles the female of the type-form of *Planema esebria* (Trans. Ent. Soc. Lond., 1898, p. 15).

Mr. Marshall gives the following account (1902) of the habits of this interesting insect:—"In its general habits *Mimacræa marshalli*, Trim., like *Acræa encedon*, is essentially a woodland (but not a forest) insect, and shows a marked fear of venturing out into open country. *Limnas chrysippus*, on the other hand, frequents both open and woodland stations. When quite undisturbed it flits about in a limited area of the bush with a slow flight exactly resembling that of *L. chrysippus* (see also pp. 481, 482), but when alarmed it is capable of flying with considerable speed, and dodges with great dexterity. When hard pressed it will occasionally rise right over the tops of the trees, descending into the bush again further on. But its usual method of escape is by dodging in and out among the tree-trunks, then settling suddenly on the far side of one of them, which makes it extremely difficult to follow. It is in its resting habits that it differs most from the mimetic group to which it belongs, for I have never seen a specimen settle anywhere except on a tree-trunk, and then always with its head downwards, just like a *Libythea* or the brown species of *Crenis*. The *Danainæ* and *Acræinæ*, on the other hand, always rest with their wings hanging down, and usually in more exposed positions; indeed, I think it may be said that no species of these groups (in South Africa at least) ever settles upon tree-trunks. This habit is also a very unusual one among our *Lycænidæ*, one or two species of *Terionima* being the only cases of its occurrence which I can recall. Despite the great resemblance of this *Mimacræa* on its under-side to *Acræa encedon*, yet its colouring when at rest is very far from conspicuous, and harmonizes a great deal better with its surroundings than might be supposed from an examination of the insect in the cabinet, especially as the fore-wings are so much depressed between the hind-wings as to quite conceal the sub-apical white patch. The species seems to be of

considerable rarity; I know of only fourteen or fifteen specimens, all of which, except two or three, were captured by myself."

C. The Origin and Meaning of the Three Chief Forms of Limnas chrysippus.

I have often discussed the question set forth in the title of this sub-section with my friend Colonel J. W. Yerbury, who has observed this insect carefully in many of its localities, and is deeply interested in it.* He believes that the appearance of the various forms is controlled by environmental influences—dryness or moisture—acting upon the pupa at some critical period of special sensitiveness. The facts recorded below do not seem to be consistent with this interpretation.

My friends Mr. and Mrs. S. L. Hinde, who have kindly collected many specimens throwing light on problems to which I have given much thought (see also pp. 446, 447), sent me two series of forms of *Limnas chrysippus*, which are of special value in relation to this discussion.

The first set (of 15) was captured, almost on the sea-level, in the uniform damp heat of Mombasa, on May 6, 1900, and consists of four of the type-form of *Limnas chrysippus* (1 ♂ and 3 ♀), and eleven of the form *klugii* (9 ♂ and 2 ♀). All were taken in less than an hour on a spot of ground a few yards in extent. They thus afford a fair criterion of the proportionate numbers of the two forms.

The second set (of 13) was taken, at a height of about 5400 ft., at Machakos Road, on the Uganda Railway, on May 22, 1900, and consists of four of the type-form (3 ♂ and 1 ♀), one *alcippoides* (♂), seven *klugii* (2 ♂ and 5 ♀), and one *dorippus* (♂). These also were taken on a spot of ground a few yards in extent, in less than an hour.

Mr. Hinde has given me information as to the climate of the period in which the latter capture was made. It is printed on pp. 447, 448, but it is well to re-state here that May 22, 1900, was at "the end of a very dry wet-season in an exceptionally dry year." The specimens show the effect of these conditions, for they are on the average

* J. W. Yerbury, Journ. Bomb. Soc. Nat. Hist., 1892, p. 207. Col. Yerbury's observations on the species are also quoted by Dr. A. G. Butler in Proc. Zool. Soc. Lond., 1884, p. 478; 1885, p. 756.

very much smaller than those bred from larvæ which fed on the more luxuriant food-plant in Mombasa. Examining the two series, we are driven to the conclusion that the Machakos larvæ were partially starved, probably by feeding on parched food-plant. Interesting and important inferences may be drawn from the comparison.

In the first place the specimens, so far from supporting the conclusion often arrived at from incomplete and, as I think, ill-regulated experiments, that males are produced by starvation, actually show a larger number of females in a smaller total of specimens than the set from Mombasa, viz. 6 out of 13, as against 5 out of 15. Even if the females had been very scarce at Machakos, nothing would have been proved in the direction of the determination of the sex of the individual by diet, for starvation pushed to the extreme of preventing the completion of development of many individuals is certain to kill off the heavier sex far more freely than the lighter. The results, however, show no abnormal excess of males, and in every way support a prediction firmly founded on the anatomical fact that the essential organs of sex, the testis and ovary, are already present, rudimentary, but perfectly distinct, in the larval stage.

A comparison of the two series furthermore indicates very strongly that the various forms of the species are not in any way due to environmental causes, but are inherent and hereditary. It is believed that *klugii* is due to drought, but there is a larger proportion of this form in the series bred in the moist heat of the coast than in that reared at high and dry Machakos. The great difference in conditions which is manifest in the different average size of the two series was powerless to effect any change in the inherent hereditary tendency of the individual to become either *klugii* or its modification *dorippus*, the type-form or its modification *alcippoides*.

This comparison of forms from adjacent localities under different climatic conditions leads to an inference which is precisely the same as that drawn from the comparison of forms from different localities under the same climatic conditions. The tropical forests of West Africa and the Malayan Islands are very similar as regards climate: in the first *chrysippus* occurs as the white-hind-winged *alcippus*, in the second as the type-form, a peculiar dark form inhabiting Java (*L. bataviana*). It is not necessary

to pursue such comparisons further. So far as *chrysippus* is concerned, I know of no facts which support the hypothesis of the environmental production of the forms, and many which are inconsistent with it.

The only alternative hypothesis which presents itself is that of the operation of natural selection in determining the very different distribution of the various forms of *chrysippus* in the different parts of its range. And in attempting to solve this difficult problem I have been guided by the same principles which enabled me to suggest a meaning for the two widely-different seasonal phases of *Precis*, viz. the relation between insects and their enemies, the value of warning colours under certain conditions, their weakness and danger under other conditions. I believe that the condition of desert areas corresponds to that of the dry season, only differing in that they are more rigid, so that cryptic colouring is still more imperative. I therefore suggest that the *klugii* form is a development in a procryptic direction in areas where the struggle is so severe that even this most unpalatable and widely-mimicked species must put off some of its aposematic appearance, viz. the conspicuous black-and-white apex of the fore-wing.

There is also a peculiar faintly greenish-orange shade in the area of the apex of the fore-wing under-side beyond the sub-apical white bar of *chrysippus* which is wanting from the corresponding part of *klugii*, the difference tending to bring about a further uniformity in the ground-colour of the under-side of the latter.

Furthermore, many specimens of *klugii* have a ground-colour quite different from that of even light individuals of the type-form, gaining a distinct sand colour. This is all the more striking in Africa, where the type-form commonly develops a dark rich fulvous ground-colour very different from the paler Oriental type.

This interpretation is based on the assumption that *klugii* has developed from *chrysippus* and not *chrysippus* from *klugii*, and no escape from this assumption seems possible. The main lines of argument are these. Island individuals, which are so generally ancestral, are *chrysippus* and only very rarely *klugii*, except near the metropolis of the latter form in Somaliland. Perfect and imperfect mimics, Batesian and Müllerian, are very-large in number, especially in Africa. Probably not one of them mimics

klugii and not *chrysippus*, a few mimic both, while the great majority mimic *chrysippus* alone. Again, *klugii* stands alone among *Danaina*, while the pattern of *chrysippus* is closely related to that of several other species and genera, such as *Salatura*. The distribution of *klugii* can be understood by supposing the desert region of Somaliland to be its centre. From this point it radiates, towards the east becoming gradually rarer, although it is well known in Karachi, and Colonel Yerbury even captured a single specimen in Ceylon, towards the south finally disappearing in South Africa, towards the Nile Valley, here also probably disappearing towards Central Africa. *Chrysippus*, or at least forms with a black-and-white apex to fore-wings, on the other hand, occur over the whole vast range of the species with the exception of certain parts of Somaliland.* The strongest argument is, however, one which is developed at the end of the section, because wide conclusions of great interest spring from it (see pp. 482-484).

The white-hind-winged *alcippus* was for a long time a great difficulty to me, but Mr. Marshall's suggestion (see p. 479) that it is a further development in the direction of still more efficient warning colours than the type-form seems to me to be sound, especially considering its distribution in the abundant life of the tropical West Coast, and considering the fact, of which Mr. Marshall assures me, that it is much more conspicuous on the wing.

I have for a long time thought that this great development of white, combined with the darkening of the fulvous ground-colour so common in African specimens and marked in *alcippus*, may indicate an incipient synaposematic approach to the black-and-white *Danaina* of the genus *Amauris*, and the large black-and-white *Acrævinæ* of the genus *Planema*.

It is in favour of this view that the darkened ground-colour appears to be a recent development, although it has arisen in the Ethiopian region—the ancestral home of the species, if we may judge by the much larger number of mimics which resemble it in this part of its range. I believe the lighter ground-colour of *chrysippus* in India and, with certain exceptions, the East generally, formerly

* Consult Dr. A. G. Butler's map of the distribution of the forms of *chrysippus*, on Plate XLVI, accompanying his paper in Proc. Zool. Soc. Lond., 1884, p. 478; also by the same author, Proc. Zool. Soc. Lond., 1885, p. 756.

prevailed in Africa, because so many of its African mimics retain this shade rather than that now borne by their model, and because *chrysippus* itself often exhibits the paler tint, especially to the north and east* of the African continent (see pp. 471, 472.).

I quote below extracts from several of Mr. Marshall's letters dealing with the hypothesis which I have here set forth, and also referring in other ways to this interesting butterfly and its forms.

"*Malvern, May 14, 1897.*—I was interested to hear that the *L. chrysippus*, var. *alcippoides*, I sent resembles the West Coast specimens. Personally I have never come across that variety commonly, and those I have taken have mostly been very slightly marked with white, but Mr. G. H. Burn, who has collected for some years in the Tugela Valley, near Weenen, says they are not uncommon there, but apparently are most prevalent in the early winter (it is a very hot dry district), and they are frequently marked quite as strongly as the one I sent you."

"*Salisbury, Jan. 24, 1900.*—Referring to your very interesting remarks on *L. chrysippus*, I was much struck by your theory with regard to *klugii*. The only point, however, on which I do not feel satisfied is whether we can consider the colouring of this variety to be really protective. Of course I have never seen it in life, but I have seen many of the *inaria* form of *Hypolimnas*, and I must confess that the insect is very far from being inconspicuous; and even apart from colour it must be remembered that slowness of flight is a very important factor in rendering an insect conspicuous (compare our large and powerfully-armed but soberly-coloured wasps of the genus *Belenogaster*). Again, it would seem hardly consistent to regard the colouring of *klugii* as protective if we rank that of the smaller *Acreas*, which inhabit some at least of the same areas, as among the warning colours. It would therefore strengthen the theory if some other use could be assigned to the *klugii* coloration, though none occurs to me at the moment. Of course the correlation argument might be brought forward; but while thoroughly appreciating Meldola's masterly defence of this principle, I must admit that I have a distinct distrust in its use in such cases, as it means virtually begging the question. I cannot altogether gather from your remarks what are your reasons

* See F. A. Dixey in Proc. Zool. Soc., 1898, p. 373, note.

for supposing that the lighter Asiatic form is the older [see pp. 471, 476]. On general principles it would seem that swamping would be likely to keep the species more or less constant in its ancestral home, whereas those specimens that wandered further afield would probably tend to vary along slightly different lines; but perhaps I have not properly caught your idea. The case of *alcippus* would be a great deal more difficult to explain satisfactorily, seeing that it occurs also at Aden; and Butler says that examples sent from such places as Monbuttu, Wadelai, etc., by Emin Pasha, showed every gradation from *chrysippus* through *alcippoides* to *alcippus*; further, if I remember rightly, you wrote me that an example I sent you from the Tugela had the white developed as strongly as in any West Coast specimen, and Burn said they were by no means uncommon there."

["A. G. Butler records (Proc. Zool. Soc., 1896, p. 243) Captain Nurse's statement that in Somaliland he bred all four forms of *chrysippus* from quite similar larvæ." G. A. K. M., 1902.]

"*Salisbury, June 26, 1900.*—Referring to the question of *Limnas klugii*, although I fully appreciate the value of your arguments, yet I must confess that when looking at the matter from the point of view of an opponent of mimicry, it seems at least open to criticism. The difficulty seems to lie in the fact that the same coloration would thus have to be regarded as both protective and warning. Now you have said that in desert regions insects would be more liable to attack owing to the paucity of insect life, and I should be glad to know whether you have any special reasons for adopting this view, as I have no experience of what the conditions of life really are in such localities. But don't you think that it is more likely that the struggle for existence would be principally against climatic conditions and not so much a competition with other organisms, and that thus probably insects would have a better *proportionate* chance of finding a living than would the vertebrates as compared with more fertile regions? If this were so it would follow that insects would be comparatively freer from attack in desert regions, and this would afford us another explanation of the *klugii* phenomenon. We might presume that the less conspicuous *klugii* colouring was the more ancestral (as seems not unlikely), but that in the more fertile regions where

insectivorous vertebrates and invertebrates are so much more plentiful, this coloration was not sufficiently striking to guard it from the tasting experiments of these enemies, and thus the white bar would be gradually developed. The typical form would therefore supplant *klugii* in all places where there was greater need of more efficient warning colouring, and the latter form would only survive in those tracts where only a limited number of insectivorous enemies could exist. Such an explanation would further throw some light on the additional development of white in the hind-wing of *alcippus* in the prolific West Coast belt, where the increased number of vertebrate enemies requiring to learn by experience renders an additional conspicuousness advantageous. It seems to me that if such an explanation could be maintained it would be more consistent with our general views; but of course the matter hinges on the conditions of life in desert tracts, which is merely an assumption on my part."

"*Salisbury, Sept. 21, 1900.*—I was much interested in your remarks on the subject of *klugii*, and I quite agree that now that you have shown that my premise as to the conditions of life in desert countries is erroneous my contention falls to the ground. I should like to know how the range of the *inaria* form of *misippus* falls in with your proposition, and also whether you find the variety of *Acræa encedon* without the white bar to follow the same range as *klugii*. I have found this variety [*daira*] extremely rare in S. Africa, but a correspondent wrote me from Beira the other day that it was not uncommon there and promised to send me specimens."

"*Estcourt, Natal; Oct. 15, 1896.*—I had thought *Acræa encedon* might be mimetic, but it must be a case of convergence—the type towards *Limnas chrysippus* and the variety *lycia* towards *esebria*. That this latter is the case I am led to believe by the fact that in Mashonaland only the type-form occurs and there *esebria* is also absent, whereas along the South-east Coast where the latter is plentiful, *lycia* occurs, and when I met with it in Durban I was struck with its resemblance on the wing to the whiter specimens of *esebria*, though this is not so apparent in the cabinet."

"*Malvern, Natal; Feb. 21, 1897.*—The case of *H. misippus* is however more puzzling than the *Euralias* which mimic *Amauris*. The *inaria* form of the female is

often cited as a mimic of *L. chrysippus*, var. *klugii*. Now this is by far the commoner form of the female *misippus* in S. Africa, whereas *klugii* appears to be extremely rare, in fact the single specimen recorded by Trimen is the only one I know of. How then can it be said to be mimicked by *inaria*? Again, *misippus* is recorded in several places in South America, where I believe *chrysippus* does not occur. It seems to require further investigation."

"*Umkomaas Mouth, Natal; Sept. 3, 1897.*—I certainly think that I have more frequently seen *Hypolimnas misippus* (female) in company with *L. chrysippus* than with its own male. The latter is fond of haunting the tops of kopjes in company with various species of *Previs* (which always occur in such localities), but I have never seen the female do so, neither does *chrysippus*."

The range of the forms of *eneceon* corresponds remarkably well with the forms of *chrysippus*. Mr. Marshall states above that the *klugii*-like form *daira* is extremely rare in the south where *klugii* is absent. Passing northward on the east side of the continent it gradually increases in proportionate numbers till it preponderates over *eneceon* where *klugii* preponderates over *chrysippus*. On the West Coast all forms seem to occur, but recently the white-hind-winged *alcippina* (Plate XV, fig. 7) has been found there in greater numbers than elsewhere. (Aurivillius, *Rhopalocera Ethiopica*, Stockholm, 1898, pp. 533, 534; Poulton, *Proc. Linn. Soc. Lond.*, 113th Session, p. 6, Report of Meeting Dec. 20, 1900, where however the name *eneceon* is erroneously printed *unicolor*.) The distribution of the Lycenid mimic corresponds equally well, *marshalli* with *chrysippus* in the south (Mashonaland), *dohertyi* with the predominant *klugii* in British East Africa. *H. misippus* ♀ shows upon the whole an almost complete lack of correspondence, for *inaria* is common nearly everywhere, while *klugii* is confined to the range described on p. 476. In British East Africa, however, *misippus* ♀ corresponds well with the two forms of its model; while on the west, where *alcippus* is the only form, the want of geographical coincidence is most striking, for the *inaria* form is relatively abundant, while neither in it nor in the type-form, so far as I am aware, is there any special tendency towards the development of white in the hind-wings. It is a striking fact that the Acraëne mimic should exhibit so close a coincidence with the geographical range of its Danaine

model, while the Nymphalino mimic shows such a marked want of correspondence. The comparison may help naturalists to realize the great importance of Müllerian mimicry and the searching selective process which has brought it about.

I have for many years attributed this want of correspondence between the commonest mimic of *chrysippus* and its model, to the wide-ranging powers of the former butterfly and its great tendency to wander, combined with some special protection which there is reason to believe it possesses, rendering its resemblance synaposematic rather than pseudaposematic. There are in the Hope Department three females (two of them *inaria*) and two males of *H. misippus* captured out of a swarm through which the ship *Winefred* passed in May 1893, when she was on the Atlantic over 500 miles from land (Ent. Record., vol. xii, No. 11, p. 315). The Müllerian resemblance of *misippus* ♀ to *chrysippus* was suggested by the present writer at the meeting of the American Association for the Advancement of Science in 1897 (see vol. xlvi, p. 242, where arguments in support of this conclusion may be found). Extracts on this subject from Mr. Marshall's letters are printed below:—

"*Malvern, Natal; Oct. 7, 1897.*—I fear I cannot at present accept your suggestion that *Hypolimnas misippus* is itself protected. I may be wrong, but in these matters I depend more than anything on the habits and actions of the insects as I have seen them when undisturbed and when frightened. There is to my mind a radical difference between mimics and their models (as opposed to convergent forms) which is often very difficult to define. There is also a structural difference which appeals to me, so that I believe I could almost tell one from the other with my eyes shut merely by the feel of it in the net. To give an instance: when on a short holiday trip to the rich Mazoe Valley in December 1894, I started out on Christmas Day with the set purpose of catching something "good" to commemorate the occasion. While strolling along the narrow belt of thick bush which there fringes the river, I saw flying leisurely in front of me what I took to be a very small and brightly-coloured specimen of *Limnas chrysippus*. I coveted it, and a few seconds later it was in my net, through the folds of which I could but indistinctly see it, so that I was still deceived. But no sooner

had my finger and thumb met across its thorax than my heart beat high with that keen excitement that every ardent entomologist feels when he has found some unexpected treasure—for I knew I had got a new mimic of *chrysippus*! A short inspection showed it to be a new Lycænid—a *Mimacræa* (since named *M. marshalli*, Trimen). On the other hand, when I caught my first specimen of *Aletis* here in Malvern in March 1893, I remember it puzzled me much, for I felt sure it was not a mimic of *chrysippus*, and yet I could not understand the reason of the colouring, for I was then unaware of Müller's theory.

"To return to *misippus*, although I admit it is a somewhat difficult case, yet the fact that it has elected to mimic what I take to be the hardest and best-protected butterfly in Africa, combined with the general adaptability to varying conditions which one would expect it to share with its nearest allies the Junonias, must I fancy go a long way towards explaining its wide range and comparatively large numbers. There is another factor that must not be overlooked, and that is that through a considerable portion of its range in South-east Africa at all events it is the only butterfly which shows mimicry of *chrysippus*. This is particularly noticeable on the rolling grass veldt of the inland plateaux where *chrysippus* is particularly abundant.

"I think your idea as to the latter insect having originated in Africa is excellent and in every way most probable."

"*Salisbury, March 6-10, 1898.*—The facts that you mention with regard to *Hypolimnas* are certainly very curious, and would seem to be only explicable by presuming the species you mention to be protected. But in the case of *Hypolimnas misippus*, after reviewing the general habits and attitude of the female, I cannot bring myself to believe that it is anything but a true Batesian mimic. Might it not be a similar case to that of the genus *Papilio*, in which we have the distinctly protected and distasteful *P. coon* and at the same time the clearly mimetic *P. cenea*?"

D. *A Study of Mimetic Forms may enable us to reconstruct the Lost Stages through which the Older Model has passed.*

If *klugii* has been derived from *chrysippus* we should expect to find traces of the markings of the latter upon the wings of the former. And as a matter of fact faint

indications of the white sub-apical bar of *chrysippus* can be detected in *klugii*, especially at the points on the costa and the hind margin which the two ends of the bar would have reached. Very faint traces of the course of the bar between these two points can be made out in certain individuals (Plate XV, fig. 1), while occasionally they are very distinct, especially upon the under-side (Plate XV, fig. 1a). Looking at these two figures, and comparing them with Figs. 1 and 1a on Plate XIV, it is impossible to resist the conclusion that we see before us the vestiges of a fading character and not the rudiments of a developing one. It is interesting to note that one of the slightly intermediate varieties of *klugii* here represented (viz. Fig. 1, Plate XV) was an individual captured by Mr. and Mrs. Hinde at Machakos Road, and that three or four others of the same set showed similar tendencies. It may be that the unfavourable conditions (see pp. 473, 474), although unable to change one form into another, nevertheless administered a shock which caused a slight reversion towards the ancestral type in some individuals.

The three great mimics of both forms of *chrysippus*, the female of the Nymphaline, *Hypolimnas misippus* with its *inaria* form mimicking *klugii*; the Acræine, *A. encedon** with its *klugii*-like form *daira*; the Lycænid *Mimacraa marshalli* with what I believe to be merely its *klugii*-like form *dohertyi*, all these show precisely the same thing as their model only in an exaggerated form, because the mimic follows its model and therefore still exhibits stages which the latter has left behind. Comparing the upper- and under-side of the *chrysippus*-like Lycænid on Plate XIV (Figs. 2 and 2a) with those of the *klugii*-like form on Plate XV (Figs. 2 and 2a), there can be no doubt that the latter developed from the former. The white bar of *marshalli* (Plate XIV) can still be distinctly traced in *dohertyi* (Plate XV), not indeed as a white bar but as a very faint paling of the ground-colour over a sub-apical area, the outline of which exactly

* The first recognition of the mimicry of *chrysippus* by *encedon*, and indeed of the existence of Müllerian mimicry in the Ethiopian Region, was first brought forward at the meeting of the British Association at Toronto in 1897 (Report, p. 689). Aurivillius (Rhop. Eth. 1898, p. 533) states that the resemblance had not been previously noticed. The account given by Aurivillius is however far more complete than that in the brief abstract here referred to, and is also accompanied by illustrations.

corresponds to the bar itself. The comparison to a pseudo-morph suggests itself; the bar is indeed absent but its shape is there. The case of the Acraëne mimic is still clearer, Figs. 3 and 3a on Plate XIV bearing the same relationship as that above described in *marshalli-dohertyi*, to Figs. 3 and 3a on Plate XV. The same "pseudo-morph" of the white bar can be seen in the latter, while in Figs. 4, 5, and 6, on Plate XV, some by no means uncommon intermediate varieties between *enecdon* and *daira* are represented. Fig. 7 shows the form *alcippina* which resembles *alcippus*, the white-hind-winged *chrysippus*.

When a geologist finds a recognizable fragment of one rock included in a stratum of another, he is usually safe in inferring that the latter is the younger. With equal confidence the zoologist may conclude that the mimicking species is younger than the species it mimics. The latter must have been in existence before the former attained a resemblance to it. From this point of view the comparison between *chrysippus-klugii* and their mimics is of intense interest. *Chrysippus* and *klugii* are now well defined the one from the other, and it is probably impossible or at least extremely difficult to get a series of intermediate forms between them. If we had not the mimics we might well believe that *klugii* arose ready-made from *chrysippus* by a process of discontinuous or transilient evolution. But two of the younger mimics are very common and widespread, and both *missippus-inaria* and *enecdon-daira* present us with abundant varieties showing every grade of transition from the one form to the other. Of the Lycænid less can be said. It is still extremely rare (see pp. 472, 473) and at present only known in two widely-separated areas. But even in it the gap *marshalli-dohertyi* has been shown above to be much less wide than that of *chrysippus-klugii*. We are led to believe from this comparison that in some earlier age the two forms of the Danaine model existed in the stage now reached by their commonest mimics, and, like these, were connected by a series of abundant intermediate varieties which have since been obliterated by selection.

E. *Amauris ccheria*-like Group: Marked Secondary Resemblances between the Forms mimicking *ccheria*.

This species of *Amauris*, with its very characteristic rectangular buff patch on the hind-wing and buff or white-

spotted fore-wing, is the dominant Danaine of South Africa, and extends in considerable abundance right up the east and east central parts of the continent well into British East Africa. It is a centre of convergence for several *Nymphalinae* and *Papilioninae* in the same district.

An interesting group, captured by Mr. Marshall at Malvern, on March 25, 1897, consists of the following species:—

Amauris ccheria, var. *albimaculata* ♂.

2 *Euralia mima* ♀.

Papilio cenea ♀, *cenea*-form, with white spots on fore-wing, like the var. *albimaculata* of *A. ccheria*.

Papilio leonidas, var. *brasidas*.

The last-named *Papilio* is a somewhat outlying member of the group, being separated from the others by the patch on the hind-wing, which is white with a faint greenish tinge, instead of buff. The general arrangement of the light markings on the black ground is however similar, and Mr. Trimen states that "it was in the habit of settling precisely in the way affected by the *Amauris*, viz. on a projecting leaf or twig, with the wings closed and hanging downward, and in this exposed position remaining motionless for a considerable time" ("South African Butterflies," vol. iii, 1889, p. 216). In two points, viz. size, and contour of the wings, it is more like the Danaine model than any of the other above-mentioned species.

The most interesting point about the group as a whole is, however, the undoubted secondary resemblance between the species which primarily resemble the *Amauris*. The secondary resemblance is, moreover, even stronger between *P. cenea* and the *Euralia* than between either of these and *P. brasidas*, that is to say, the species exhibiting a closer primary mimicry also exhibit a closer secondary mimicry. This fact suggests that the secondary resemblance is of permanent value and not a mere phase which will ultimately be lost in the primary resemblance. Mr. Marshall informs me that these secondary mimetic resemblances are still more marked upon the wing, so that a naturalist may often be sure that he sees before him a mimic of *ccheria* or of a black-and-white *Amauris*, but cannot in any way distinguish the mimic itself as *Papilio*, *Pseudacraea*, *Hypolimnas*, etc.

The points in which the mimics of *A. ccheria* converge together and diverge from their primary model are as follows:—

- (1) Size: They are much larger than their primary model. *Brasidas* is in this respect intermediate.
- (2) Scalloped outline of hind-wing; feebly marked in *brasidas*. Slight indications of scalloping are intensified in *ccheria* by the fringe being marked by two white spots in each of the shallow concavities. This is only distinct in some individuals, apparently chiefly from the northern part of the range. The marked concavities of the mimics are also intensified by whiteness.
- (3) Elongated oval shape of largest spot in fore-wing, viz. the spot below the cell, while that of the model is nearly circular. The long axis of the oval spot furthermore assumes the same direction in each of the three species, while that of *ccheria* is entirely different.
- (4) The much greater prominence in all three mimics of the sub-marginal row of white spots on the upper-side of both wings.
- (5) Strongly-marked black internervular rays pass inwards from the margin of the hind-wing of *Euralia* and invade the periphery of the ochreous patch, uniting with the black veins to make up a pattern of radiating dark lines. The radiate appearance of the under-side is even more prominent than that of the upper-side. *Papilio cenea* ♀ is very similar, except that the upper surface exhibits only faint indications of the character (which however is strongly marked in the *hippocoön* form resembling *Amauris dominicanus*).*

Some of these differences between mimics as a whole

* In this respect, viz. the prominent development of internervular rays on both surfaces of the hind-wing, the *hippocoön* form of the Western *P. meope* presents a far closer resemblance to its co-mimic *Euralia anthedon* than to the primary model *Amauris niarius*, and similarly the *hippocoön* form of the Southern and Eastern *cenea* and *Euralia wahlbergi* than to *Amauris dominicanus*. Not only is there the conspicuous radiate appearance wanting in the Danaïne model, but the white centre of the upper surface of the wings deepens gradually at its margin into black in both *Papilio* and *Nymphalid*, while the margin of the corresponding white area in the Danaïne exhibits an extremely sharp and abrupt transition into black.

and their primary model are less pronounced in the northern part of the range, in British East Africa, where the *Amauris* is often larger and commonly possesses far more distinct sub-marginal spots on the upper-side. It is interesting to compare other mimics of *echeria* with the members of the group captured by Mr. Marshall at Malvern on March 25, 1897.

The female of *Pseudacraea turquinia* is a poorer mimic of *echeria* than *Euralia nima* and *Papilio cenea* ♀, although upon the wing the resemblance is doubtless strong. In size it closely approaches the model: it has a slightly-scalloped border, and an irregular oval spot with a direction similar to that of the other mimics; the marginal spots are small as in the southern *echeria*. On the under-side of the hind-wing is a basal brown patch with conspicuous round black spots as in many Planemas. In the development of internervular black stripes invading the squarish ochreous patch on the hind-wing it resembles *Euralia* and diverges from the Danaïne model.

The female of *Papilio jacksoni*, in the shape and direction of the spot below the cell on the upper-side of the fore-wing, far more closely resembles *echeria* than any other mimic I have seen. On the other hand, the hind-wing is deeply scalloped, the effect being much intensified by white-margined concavities, the sub-marginal spots are as a whole larger than those of any other mimic, while the under-surface of the hind-wing exhibits very little approach towards the *Amauris*, retaining the basal, black-spotted brown triangle of the male, that well-known synaposeme and pseudaposeme of many Ethiopian Papilios, Planemas, Acraeas, Elymnias, Pseudacraeas, etc., unknown in the Ethiopian *Danaïnae*. Thus, in addition to its primary mimicry of *echeria*, var. *albimaculata*, *jacksoni* manifests secondary mimetic resemblance to the former group of Rhopalocera, especially the Planemas, and also an approach to other mimics of *echeria* in its conspicuous sub-marginal spots and deeply-scalloped border. The general effect of the spotting of the fore-wing is also more like that of *P. cenea*, and even of *Euralia nima*, than its primary model.

The female of the south-eastern *Papilio echerioides* is very similar to that of *jacksoni*, but the spot below the cell of the fore-wing is oval and in shape and direction more nearly resembles that of *Papilio cenea*.

F. *The Origin of the black-marked, golden-brown Triangle at the base of the Hind-Wing under-side in many Ethiopian Butterflies.*

Mr. Roland Trimen, F.R.S., considers that the black-marked, triangular, golden-brown basal patch on the under-side of the hind-wing of the female *P. cynorta* which mimics *Planema gea*, and *P. echerioides* [and we may now add *P. jacksoni*] "points to the inference that mimicry of the *Planema* group was in both these *Papiliones* the earlier tendency, and has only more recently been diverted in the direction of *Amauris* in the case of the Southern species"; for "this character is in the ♂s of *cynorta* and *echerioides* even more developed than in the ♀s, and is in direct mimicry of the *Planema*" ("South African Butterflies," vol. iii, 1889, p. 258). But if in the female of *cynorta*, which is admitted to be an excellent *Planema* mimic, this very character is reduced, how can it be believed that its greater development in the male is a case of direct *Planema* mimicry, seeing that in every other respect this sex, if a mimic at all, is a most imperfect one?

A comparison of the *Papilios* and *Planemas* with the most remarkable development of this warning character at the base of the under-side of the hind-wing renders it probable that in this respect the latter have acted as Müllerian mimics rather than models. The character is far more highly developed and specialized in a section of Ethiopian *Papilios* than in any of the *Planemas*: it also appears in forms which are unknown, and accompanied by other warning characters which are also unknown in the *Planemas*; it reaches its highest development in species which do not mimic *Planemas*. It is also probable that the conspicuous, sharply-outlined white band of the male *echerioides*, *cynorta*, etc., nearly alike on both upper- and under-sides, is a warning character peculiar to this group of tailless Ethiopian *Papilios*. In the most strongly-marked species, with sexes nearly alike (*zenobia*, *cypræofila*, etc.), the outer margin of the band on the fore-wing is coarsely serrated in a very characteristic manner on both surfaces. Furthermore (in *cypræofila*, *gallicus*, etc.), another warning character of great interest is added in the row of large conspicuous marginal white spots on both surfaces of the hind-wing and smaller ones on the fore-wing. In this respect this group of *Papilios* presents an exact

negative of the positive form of synaposeme characteristic of the Pierine genus *Mylothris*. Thus very striking warning characters are peculiar to this section of Papilios, the fifth or Zenobia Group of Aurivillius; and, furthermore, the character we are specially considering, the black-marked basal patch of the under-side of the hind-wing, assumes a form which is unknown in *Planema*, being traversed by blackened veins and broader black internervular lines. In the species of *Papilio* last mentioned there are no spots upon the brown triangle, only these strongly-marked radiating lines. In *zenobia* and still more in the male *cynorta* a few spots are added by modification of some of the other markings, and it is probable that this slight change is a late diaposematic response to *Planema*, made after the latter had gained the golden-brown triangle in Müllerian mimicry of these dominant Papilios.

Another important point is the fact that the golden-brown triangle is *larger* in the females than the males of *cyparofila* and *zenobia* which do not mimic Planemas, *smaller*, as has already been pointed out, in the females of the species which strongly exhibit this Müllerian approach to either *Planema* or *Amauris*.

It must also be remembered that Papilios may be excessively unpalatable to insect-eating animals as a whole. Thus Mr. Frank Finn concludes that *P. aristolochiæ* is more distasteful to birds than *Danainæ*, *Acræa violæ*, and *Delias eucharis* (Journ. Asiat. Soc. Beng., lxvii, pt. ii, 1897, p. 614).

The facts and arguments set forth above render it probable (1) that the golden-brown triangular patch first arose in the Zenobia Group of Ethiopian Papilios; (2) that it was later reproduced on a smaller scale by the Acræine genus *Planema*, the Acræine round black spots contrasting with the ground-colour in place of the radiating black lines of the *Papilio*; (3) that, later still, other widely-separated genera reproduced the character in the form it had assumed in *Planema*, e. g. *Pseudacræa*, *Elymnias*, etc., while a reciprocal (diaposematic) tendency (see p. 426) to approach the *Planema* form is seen in certain species of the Zenobia Group of Papilios. Several species of the group have females mimicking Acræines or Danaines. In the three of these which were examined the males exhibited the above-described diaposematic tendency, while the females possessed a greatly-reduced but otherwise similar triangular patch.

Hence this characteristic widespread Ethiopian synaposeme and pseudaposeme has probably originated in a diaposematic fusion of the triangular golden-brown patch of the Zenobia Group of Papilios with the scattered circular black spots which are characteristic of Ethiopian *Acraeas*. I have made much use of Aurivillius' admirable "*Rhopalocera Ethiopica*" in this section which is devoted to the discussion of an under-side synaposeme, although the distinguished author himself maintains that mimetic resemblance is almost confined to the upper-side of butterflies' wings—a very strange conclusion (*loc. cit.*, p. 535).

G. *Compound Group containing Representatives of all the three previously described. Species probably entering two Groups.*

The groups described above fly together, and thus represent in a compound group the chief types of butterfly coloration which a young insect-eating animal of South and Eastern Africa requires to learn, by a trial of one or more representatives. The following members of the three groups were captured by Mr. D. Chaplin at Berea, a suburb of Durban, on April 5, 1896, and are now in the Hope Department.

BLACK-AND-WHITE GROUP.

Echeria-LIKE GROUP.

Amauris ochlea.

Amauris echeria, var. *albi-*

Planema aganice ♀.

maculata.

Euralia mima.

Chrysippus-LIKE GROUP.

Limnas chrysippus ♂.

2 *Hypolimnas misippus* ♂, ♀ type-form.

2 *Acraea petraea* ♂ ♀.

2 *Acraea encedon*, type-form and var. *Lycia*.

That the same species may produce two or more forms entering as many groups is well known, but, as a rule, such polymorphism is confined to the female sex. In the polymorphism of *Acraea encedon*, however (see pp. 483, 484), we have a case in which both sexes are present in the various forms, and although the relative numbers of the forms are very different and certain of them may perhaps be absent from a district, I know of no case in

which one alone is found in any part of the total range of the species. Hence the polymorphism, although partially a distributional phenomenon, is not entirely so. On the other hand, I know of no example among the Lepidoptera in which a species is at the same season divided into two sub-equal sections throughout its range, each containing both males and females, and each section mimicking a very different model. Among Diptera, the European *Volucella bombylans* and its form *mystacea* supply good examples; and now Mr. Marshall has collected evidence which makes it in the highest degree probable that the Lepidoptera are not without such cases. He brings convincing support for the belief that *Euralia wahlbergi* and *E. mima* are the two forms of a single species. It is greatly to be hoped that Mr. Marshall may be as successful in establishing this interesting and unique case, as he has been in the marvellous seasonal transformation of *Precis*. His evidence is set forth in the following quotations from his letters:—

“*Umkomaas Mouth, Natal; Sept. 3, 1897.*—In my own mind I am pretty well convinced that *Euralia mima* and *wahlbergi* are one and the same species which has developed two mimetic forms as in *Papilio cenea*, but that in this case both sexes are concerned. My reasons for so thinking are that they have been taken *in coitu* several times, that specimens occur presenting intermediate coloration, and also that the two forms are always found together whenever they are met with in any number. I have not often been fortunate enough to see these congregations, but I remember seeing some thirty or forty specimens, comprising about equal numbers of each form, collected together on the side of a steep shady kraantz along the Palmiet River. Mr. A. D. Miller, who has collected for many years in Durban, tells me this is by no means uncommon, and that they congregate particularly in the afternoon when going to roost. Mr. C. N. Barker tells me that some years ago he came across a large number of both forms on a large tree on which they had evidently bred, for many of them had only just emerged, and some had not their wings fully developed. This shows that they are also associated in their earlier stages.”

About the time when this passage was written Mr. Marshall presented to the Hope Department a set of eight individuals of these Euralias, viz. four of *E. mima* (2 ♂,

2 ♀), and four of *E. wahlbergi* (3 ♂, 1 ♀), which he had captured on the Umbilo River, near Durban, Natal, on June 28, 1897. His account of the habits of this little company is given below.

"*Malvern, Natal; Oct. 7, 1897.*—The specimens of *Euralia mima* and *wahlbergi* were captured going to roost together on a small clump of ferns under a steep kraantz between 3 and 4 p.m. Although disturbed a good many times in my efforts to catch them, they always returned after some minutes. There were two others which were too tattered to keep, and two more that I failed to catch."

If Mr. Marshall's conclusion be established, it follows that the corresponding and closely-allied mimetic West African forms *Euralia anthedon* and *E. dubia*, connected like *wahlbergi* and *mima* by intermediate varieties, are similarly the dimorphic forms of a single species.

H. Groups of Synaposematic *Acræas* captured at the same Place and Time.

Professor Meldola first suggested the use of Fritz Müller's principle to explain "the prevalence of one type of marking and colouring throughout immense numbers of species in protected groups, such as the tawny species of *Danaïds*, the barred *Heliconias*, the blue-black *Euplexas*, and the fulvous *Acræas*" (Ann. and Mag. Nat. Hist., ser. 5, vol. x, 1882, p. 425). As an example of Müllerian mimicry in the last-named group, I was anxious to obtain convergent species captured in one place and at one time. Mr. Marshall very kindly obtained two such groups for me. The first was captured by him on Dec. 31, 1898, at Salisbury, and contains the following species:—

- 6 *Acræa doubledayi*, var. *avina*, 4 ♂ 2 ♀ (♂ Fig. 1, ♀ Fig. 2, Plate XVI).
- 4 *Acræa caldarena*, 3 ♂ 1 ♀ (♂ Fig. 3, ♀ Fig. 4, Plate XVI).
- 4 *Acræa nohara*, var. *halaki*, 2 ♂ 2 ♀ (♂ Fig. 5, ♀ Fig. 6, Plate XVI).
- 2 *Acræa violarum*, var. *asema*, 2 ♀ (Fig. 9, Plate XVI).
- 2 *Acræa rahira*, 1 ♂ 1 ♀ (♂ Fig. 7, ♀ Fig. 8, Plate XVI).

All these species are of approximately the same size and shape of wing, colour, and pattern, *rahira* being furthest

removed from the average appearance of the group, while *caldarena* is an outlying member in one respect only, viz. the pronounced apical black patch on the fore-wing. The brightly-coloured males and the brightest of the females of all these species would closely resemble each other on the wing, including the male of *violarum*, which was not captured on that particular day; and similarly a uniform effect would be produced by the darker females. The under-sides of all species except *ralhira* are superficially alike. The strong superficial resemblance is well shown in Figs. 1 to 9 on Plate XVI.

A second group was captured at Salisbury on Jan. 7, 1899, and contains the two following species:—

2 *Acræa anemosa* ♂ ♀ (♀ in Plate XVI, fig. 10).

2 „ *natalica* ♀ (Plate XVI, fig. 11).

These large *Acræas* are obviously very different in the details of coloration, but the positions in which the black marking of the upper surface are massed on the fulvous ground-colour are almost exactly the same, the only marked difference being the presence of numerous black spots in the first-named species which are almost absent in the second. Mr. Trimen speaks of *anemosa* as “in habit and general colouring very near *natalica*” (*loc. cit.*, vol. i, p. 156). The under-sides are far less alike, but there can be no doubt about synaposematic convergence having occurred. It is probable that the approach has been chiefly, perhaps entirely, on the side of *natalica*, which has adjusted markings of a type usual among Ethiopian *Acræinæ* in such a manner as to produce superficial similarity to *anemosa*, an *Acræa* in which a very remarkable and unusual appearance is the warning sign of exceptional defence against insect-eating animals (see p. 413).

Mr. Marshall informs me that the two species are very similar upon the wing, and that the resemblance is much closer in the case of the female *natalica* than the male, thus following the rule in mimicry, and confirming still further the opinion expressed above that the approach has been from the side of *natalica*.

I. *Mimetic Species of South African Lycaenidæ and Hesperidæ captured with their Models.* .

Exclusive of *Mimacræa marshalli* and its form *dohertyi*

which were discussed in relation to their models *chrysippus* and *klugii*, the groups containing *Lycanidæ* or *Hesperidæ* are considered below.

A group of the smaller *Acræas* with a single mimetic *Lycanid* was captured at Salisbury on Sept. 28, 1900. It contains the following species:—

- 2 *Acræa violarum*, var. *asema* ♂.
- 1 „ *doubledayi*, var. *axina* ♂.
- 1 „ *induna* ♂.
- 1 *Catochrysops mashuna* ♂ (figure of ♀ on Plate XIV, fig. 5).

A. induna falls into the first-mentioned group of small *Acræas*, resembling *caldarena* in the possession of a black apical patch to the fore-wing. The strong development of black spots upon an ochreous ground on the under-side of the *Lycanid* is doubtless mimetic in the position of rest, especially when in the company of *Acræas* or in places where they are likely to be found. Mr. Marshall informed Mr. Trimen “that on October 20, 1894, he saw two of this *Lycæna* sleeping on the end of a stem of dry grass among a number of *Acræa nohara* and *A. caldarena*, and was struck with the general similarity of their under-side to that of the *Acræas*; he also noticed that in the attitude of repose the fore-wings of the *Lycæna* were well depressed between the hind-wings, giving the insect the elongate outline of an *Acræa*” (Trans. Ent. Soc. Lond., 1898, p. 6). Mr. Trimen also suggests that the heavy black spotting of *L. (C) gigantea* and *L. (C) perpulchra* (Trim.) [= *peculiaris*, Rog.] is of the same significance, although the ground-colour is not *Acræa*-like in these species.

A paragraph from one of Mr. Marshall's letters is quoted below.

“*Umkomaas Mouth, Natal; Sept. 3, 1897.*—The under-side of the *Acræa*-like *Lycanid* *L. mashuna* is ochreous yellow with large black spots, but I did not realize its resemblance to an *Acræa* until I saw them roosting together. The mimicry, however, is in a very incipient stage, for the yellow under-side fades somewhat rapidly, thus much lessening the resemblance; and, as it does not occur in its near allies *L. hypoleuca* and the fine *L. gigantea*, it is clearly a recently-acquired character.”

In another group captured at Umtali, 3700 feet, in December 1900, the *Acræas* are only represented by a single

species, and that not specially suitable as a model for the other members. The great interest of the assemblage is the presence of a rare Hesperid, *A. tettensis*, in which black spots and a pale pinkish tinge on the under-side of the hind-wings appear to indicate strongly-marked mimicry of *Acræas* on a line along which the above-named *Lycænids* have advanced to a greater distance. In another respect, however, viz. the strongly-marked black-and-white margin of the hind-wing under-side, the Hesperid is a much closer mimic of a general *Acræa* type. Mr. Trimen also speaks of the spotting and tinting of the under-side of both wings of this species as very peculiar and strongly recalling the aspect of some of the smaller *Acræas* (*loc. cit.*, vol. iii, p. 338).

I have received from Mr. Marshall the following references to the two Hesperids in the list of species making up this group :—

“*Salisbury, Jan. 11, 1901.*—I have recently obtained at Umtali another Hesperid, the very rare *Abantis tettensis*, showing strong *Acræoid* coloration on the under-side, which I will send you together with a *Kedestes*, which is of interest as it shows the incipient stages of such mimicry.”

“*Salisbury, Sept. 27, 1901.*—I have never seen *Abantis tettensis* with its wings closed over its back ; all that I have captured rested with wings expanded horizontally. Indeed I cannot at the moment recollect ever seeing any *Abantis* settle with vertical wings. I think it is highly probable that *tettensis* would sleep in that position, but under the circumstances I should not like to assume it as a fact without actually seeing it.”

The group is as follows :—

- 3 *Acræa encdon*, type-form.
- 2 *Catochrysops peculiaris* (Plate XIV, fig. 4).
- 2 *Abantis tettensis* („ „ „ 6).
- 1 *Kedestes macomo*, var. („ „ „ 7).

In the latter Hesperid the brilliant ochreous under-side affords an effective background for the small but distinct black spots on the under surface of both wings. The general effect is somewhat *Acræa*-like, but the tint of the under-side of most smaller *Acræas* is pinkish when they are fresh.

A more perfect Hesperid mimic is seen in the rare *Baoris netopha*, of which a female (Fig. 13, Plate XVI) was

captured by Mr. Marshall at Salisbury on April 6, 1898, together with a male of *Acræa doubledayi*, var. *avina* (Fig. 12, Plate XVI), which is one of the many smaller *Acræas*, to which it bears a somewhat generalized resemblance on the under-side of its wings in the natural position of rest, which is nearly but not quite represented in Fig. 13 (see the description of the Plate). Mr. Marshall has sent the following account of the attitude:—

“*Salisbury, Feb. 12, 1899.*—The *Baoris netopha* rest with closed wings, and the fore-wings pressed well within the hind-wings so as to hide the white spots; they then look much more *Acræa*-like.”

The curious reticulate under surface of the hind wings of the isolated and remarkable Hesperid *Cyclopides willemi* is mimetic of the probably distasteful *Alæna nyassæ*, which possesses a somewhat similar but much coarser reticulation. Mr. Marshall states that the resemblance is much enhanced in the resting attitude of both species by the concealment of the fore-wings, with the exception of the apex, within the hind. Both species frequent the same localities, and both rest upon grass-stems. One of each species was captured at Salisbury on Feb. 23, 1901, and another similar pair on March 3, 1901.

In thus bringing together Mr. Marshall's examples of mimicry in *Hesperidæ*, it is appropriate to include the following interesting case of mimicry on the part of a Hesperid for a Danaine larva.

“*Salisbury, March 10, 1898.*—The larva of the large ‘skipper’ *Rhopalocampa forestan* possesses a colouring wonderfully similar to that of *L. chrysippus*, though it lacks the filaments. I only know the larvæ of three other species of *Hesperidæ* and they are all green; moreover, they form shelters for themselves, and never come out to feed except after dusk; whereas, although *forestan* also forms a shelter, yet it frequently comes out and feeds in broad daylight, when it is a very conspicuous object.”

The upper-side of *Alæna nyassæ* appears to fit in with the strong combination of black-and-white Ethiopian butterflies belonging to the *Danainæ* and *Acræinæ* and their Batesian and Müllerian mimics. Among the smaller of the latter *Neptis agatha* is probably to be placed, and this species is on the wing with the much smaller Lycænid. Thus Mr. Marshall has sent to the Hope Department specimens of the *Neptis* captured at Salisbury on March

19 and May 1, 1898, and of the *Alæna* taken on March 20 and April 3 of the same year.

It occurred to me that *Castalius calice* might also belong to the same group, but Mr. Marshall points out, in the passage quoted below, that its habits do not support this view.

"*Salisbury, Jan. 8, 1899.*—I should very much doubt whether *Castalius calice* is convergent with or even a mimic of *Alæna nyassæ*. Their habits and stations are very different, and moreover *C. calice* (of which I believe *C. melæna* will prove to be the summer form) is common in Natal and the Transvaal, where *A. nyassæ* does not occur. I should not regard *C. calice* as an unpalatable species, and its colouring is by no means conspicuous owing to its small size: it is an active little insect resembling *T. plinius*, *Lycænesthes*, and other arboreal *Lycænidæ* in its habits. In the intense light and shade of this climate its black-and-white markings are rather protective as it rests on the shiny leaves of its food-plant (*Zizyphus*), just as are the brilliant white under-sides of some *Iolai*. The convergence you suggest between *A. nyassæ* and *Neptis agatha* and *Nyctemera leuconoë* is highly probable, but *Amauris* and the black-and-white *Acraeas* are all absent from the Mashona plateau, being all coast or low-veldt forms. *Alæna*, *Pentila*, and perhaps *Deloneura*, are in my opinion the only unpalatable South African *Lycænidæ*, and the latter is more likely to be a mimic of some day-flying moth. *Catochrysops mashuna* used to be very abundant here, but only occurring in September and October. I only saw two or three this season and always when I had no net."

Three specimens of another interesting and probably distasteful species of the same *Lycænid* genus *Alæna amazoula* captured on the same day, Sept. 26, 1897, as the conspicuous day-flying and probably unpalatable geometrid moth *Petovia dichroaria* were presented by Mr. Marshall to the Hope Department. Mr. Marshall had taken the group in the same locality at Malvern, Natal, and, as the passage from his letter quoted on p. 498 indicates, he believes that the resemblance is synaposematic. In the cabinet the likeness is stronger on the under than upon the upper surface, but is probably strongest of all upon the wing.

Alæna amazoula is a *Lycænid* of great interest, probably exhibiting a generalized Müllerian resemblance to the

Acræas. Although unlike any single species of *Acræa*, the likeness to this group and unlikeness to the *Lycænidæ* was sufficient to deceive Boisdual and at first Roland Trimen (Rhop. Afr. Austr., 1862-66, p. 111). In the Hope Collection also I found it had been placed among the *Acræas* by Professor Westwood. Its undoubted *Lycænid* affinities were finally established by Roland Trimen ("South African Butterflies," vol. ii, 1887, p. 222).

The above-mentioned errors as to the affinity of this aberrant *Lycænid* certainly support the opinion that it bears a general resemblance to the *Acræinæ*. It would be interesting to know its resting habits. With the under-side exposed and the long narrow wings it would probably bear some general likeness to a very small *Acræa*. Mr. Marshall wrote concerning it as follows:—

"*Umkomaas Mouth, Natal; Sept. 3, 1897.*—*Alæna amazoula* is certainly a protected species, but I do not think it is in any way convergent towards the *Acræas*, for it is in no way suggestive of them on the wing, being by no means conspicuous, but rather difficult to follow. Its length of wing has been attributed to relationship with *Acræa*, but this seems open to doubt. I should prefer to consider it as a parallel development to *Acræa*, though it is worth noting that the allied genus *Lachnocnema* has also somewhat elongate wings."

"*Malvern, Oct. 7, 1897.*—The day-flying moths [*Petovia dichroaria*] captured on the same day as *Alæna amazoula* can, I think, be well regarded as convergent in coloration."

J. *Mimicry in Lycænidæ and to a less extent in Hesperidæ a Character of the Ethiopian Region. Possible Interpretation.*

The instances of mimicry in South African *Lycænidæ* recorded here, and the much larger number known in other parts of the region, especially the tropical West Coast, led me to inquire how the total number of species of this family compared with that of other parts of the world. My friend Mr. Hamilton Druce kindly made an approximate calculation of the number of described species in the two other great tropical south-extending land masses. From Australia, the Malay Archipelago, and the continental portion of the Oriental Region, over 1000 species have been described. From the Neotropical Region

about 700 species of *Thecla* have been described. In Aurivillius' catalogue of Ethiopian Rhopalocera only 582 species are recognized. The predominance of Lycænid mimicry in this latter Region is therefore in no way connected with richness in the number of species. The chief reason is certainly the existence in the Region of the sub-family *Lipteninae*, with nearly all its species mimetic. In addition to the general Acræine appearance of *Alana amazoula*, the *Neptis*-like *A. nyassæ* and the *chrysippus-klugii*-like *Mimacraa marshalli-dohertyi*, there is represented in the Hope Collection mimetic resemblance to *Terias* or other small Pierines on the part of *Larinopoda lircæa*, *L. tera*, *Liptena libyssa*, and *L. undularis*; to *Mylothris* by *Pentila abraxas*, *P. phidia*, and *Citrinophila erastus*; to *chrysippus* and the *chrysippus*-like *Euphædræ* and *Aletis* by *Telipna bimaculata* and *T. sanguinea*; to a general Acræine type by two or three species of *Pentila*. Many other cases of mimicry are known in the sub-family, especially towards models of the genera *Planema* and *Acræa* (see Aurivillius, *loc. cit.*, p. 530). But this remarkable group does not by any means exhaust the Ethiopian Lycænid mimics, for many species of the *Lycæninae* mimic Acræas, *Terias* or other small Pierines and *Mylothris*. The general Acræine mimicry of species of *Catochrysops* has already been described and illustrated. Furthermore, Aurivillius considers that there is a certain amount of mimetic approach between species of *Lipteninae* and *Lycæninae* in which the former probably always act as models.

It is very difficult to understand this predominance of Lycænid mimicry in the Ethiopian Region, and I can only suggest the possibility that the number of feasible models of moderate and small size furnished by the abundant Acræinæ of Africa may furnish an explanation. In such cases as *Catochrysops peculiaris* and *mashuna* we see at once how naturally and easily the Lycænid under-side adapts itself to the characteristic appearance of the *Acræa* type, especially when it is further assisted by similar habits. And this suggests another equally important principle which has doubtless been fertile in bringing about Lycænid mimicry, viz. the habits of the models being such as to bring them within the range of the forms which were to mimic them. The numerous low-flying and low-settling Acræas, resting at night on grass-stems, have precisely the mode of life which is well known to be characteristic of

such a large number of *Lycænidæ*. The *Lipteniniæ* are probably a specially-protected group, and the rarity of many of the species may be only apparent, and due to their (Müllerian) mimicry of extremely common forms for which they are constantly mistaken by naturalists.

In other parts of the world *Lycænidæ* which are evidently specially protected and extremely conspicuous are well known, such as *Talicada* of the Oriental Region and *Eumæus* of the Neotropical. These genera do not enter into synaposematic association with the best-defended butterflies of their localities, but each adopts an aposematic appearance peculiar to itself. It is probable that in the Neotropical Region, where mimicry is more striking and more fully exemplified than in any other part of the world, the habits of the *Theclæ* are the chief obstacle to their use of this means of protection. For models of all sizes abound in this part of the world. On the other hand, in the tropical East it may be the want of a sufficient number of models of an appropriate size and habits which has acted as the barrier.

The explanation which has here been thrown out as a suggestion may also enable us to understand the cases of mimicry in Ethiopian *Hesperidæ*, a family in which such resemblances are rare. Here, however, the facts may be paralleled in the Neotropical Region where there are a few mimetic "skippers." Mimicry in this group and the want of it in the *Lycænidæ* may follow from the difference between the habits and stations of the tropical American *Hesperids* and *Theclæ*.

K. *Mimicry in the Nymphaliniæ Batesian or Müllerian?*

I have had much controversy with my friend Mr. Marshall over this difficult and interesting problem, and I propose to bring forward a résumé of the arguments which seem to support the latter interpretation as opposed to the former, and then to quote his weighty objections and the interesting observations of the habits of mimetic species and genera which he has made.

1. It is of interest although probably not of extreme importance to reflect that all the great groups of unpalatable, conspicuous, and much-mimicked butterflies belong to the *Nymphalidæ*—the *Ithomiinæ*, *Danainæ*, *Heliconinæ*, and *Acraeinæ*, and that the two latter are so

closely related to the *Nymphalinae* that it is difficult to draw a line between them. The argument is not of much weight, because the intensely procrryptic habits and colours of many Nymphaline genera have certainly been brought about by selection due to the great keenness and success of insect-eating animals in their pursuit. I have however suggested and brought evidence in support of the view that some of the procrryptic Nymphaline species are to a certain extent unpalatable (see p. 442).

2. Mimicry in the *Nymphalinae* does not appear in isolated forms but in all or nearly all the species of a genus. Such mimetic genera are usually very large, dominant, and wide-spread. The species themselves are also often wide-spreading, and may have an enormous range far exceeding that of the model (*Hypolimnas misippus*). Allowing for the fact that the mimetic species resemble the commonest types in the world, and so are liable to escape notice, it is probable that they are rich in individuals. In many instances we know that this is so. The more we investigate it the more does Rhopaloceran mimicry seem to be associated with dominant genera and species, rather than the feeble and hard-pressed forms which H. W. Bates presupposed in his well-known theory.

3. The dominant tendency towards mimetic resemblance in any genus cannot be explained by hereditary transmission of the mimetic form of a single parent species, or from the tendency of closely-related species to vary along nearly the same lines, because the species of a mimetic genus, as a matter of fact, mimic in many different directions. Thus *Pseudacræa* resembles *Acraea*, *Planema*, *Amauris*, and *Limnas chrysippus*; while *Hypolimnas*, including *Euralia*, is even more protean.

4. The non-mimetic species of a mimetic genus are often markedly conspicuous, exhibiting what has all the appearance of an aposematic pattern peculiar to themselves (*Hypolimnas*, *Pseudacræa*). This is also frequently true of the non-mimetic males of a species with mimetic females (*Hypolimnas*). Such aposematic patterns are especially displayed on the under-side, where procrryptic colours are developed in other butterflies.

5. The converse of the last argument is also true, viz. some of the species in a genus, which is as a whole markedly conspicuous and itself mimicked, are often mimetic of quite other groups. Many instances of *Neptis*

have been given on pp. 467, 468, and mimetic species are also well known in *Limenitis*, *Cethosia*, etc.

6. The non-mimetic species of mimetic genera are sometimes mimicked; e. g. the mimicry of the *nerina* form of female *Hypolimnias bolina* by a rare *Danaine* in Celebes, etc. The resemblance of the upper-side of certain species of *Protoponomorpha* to some of the larger species of *Hypolimnias* may be another instance of the same tendency.

7. The fact that mimetic species resembling some primary model nevertheless in certain respects resemble each other rather than the model. This deuterosynaposematic resemblance, as it may be called, is a very widespread phenomenon, and several striking instances of it are discussed in the present memoir (see pp. 470, 471, 485-7). It will also be shown to occur in Coleoptera (pp. 513-515).

I have given merely an outline of the chief evidence which has induced me to believe that the mimetic Nymphaline genera are to some extent specially protected, and thus have developed a beneficial synaposematic association with far better protected forms belonging to other sub-families.

This evidence has been sought and obtained under the guidance of the principles discovered by Dr. F. A. Dixey and ably presented by him in 1894-97 (Brit. Assoc. Reports, 1894, pp. 692, 693; Trans. Ent. Soc. Lond., 1894, p. 298; 1896, p. 65; 1897, p. 317). These memoirs mark one of the few important advances made in our attempt to understand the complex and difficult phenomena of mimicry. I will quote one pregnant paragraph, which it will be seen contains the essence of what I have here described as primary and secondary mimicry (see pp. 513-515, also the above paragraph 7). "Every conspicuous and distasteful form is a centre of attraction for other forms, whether edible or inedible; but in the former case (Batesian mimicry) the mimetic attraction is limited in operation, and acts only in one direction, influencing nothing but the mimic; while in the latter case (Müllerian mimicry) the mimetic attraction is unlimited and mutual, acting reciprocally in both directions, and influencing each member of the group" (Trans. Ent. Soc. Lond., 1897, pp. 324, 325).

Mr. Marshall's valuable notes on the habits of Nymphaline mimics and his discussion of the conclusions described

above, are contained in the following quotations from his letters.

"*Malvern, Natal; Feb. 21, 1897.*—As regards the *Euralias* my experience of them is somewhat limited, but from what I have seen of them I feel pretty sure that their coloration is due to mimicry and not to convergence. Their range seems in all cases to agree with that of the *Amauris* they resemble. In Durban *A. ochlea* is by far the scarcest of the three, and its mimics *E. deceptor* and *Pseudacraea expansa* are also very rare; further up the East Coast, however (Delagoa Bay and Beira), *ochlea* becomes one of the commonest of the genus, and the two other species are likewise much more numerous. At this place, it is true, *Euralia wahlbergi* is certainly more plentiful than *A. dominicanus*, but they are both uncommon, and all the specimens we see are practically visitors from the thick bush along the immediate coastline. (This is six miles inland.)"

* * * * *

"I may mention that in the last few years Mr. Ball has caught two *Euralia wahlbergi* [in the Karkloof Forest twenty miles N. of Maritzburg], but has never seen *Amauris dominicanus*."

"*Umkomaas Mouth, Natal; Sept. 3, 1897.*—With regard to the *Euralia*, etc., I must admit that I have never been fully convinced by the contention that in Batesian mimicry the mimetic species must *of necessity* be a feeble one and very few in numbers. It seems to me that it would be quite reasonable to suppose that such a mimic might well equal or even exceed in numbers the protected species, though this would of course depend entirely upon the degree of inedibility of the latter. For example, in the case of *Euralia mima* and *Amauris echeria* (probably the best-protected butterfly here), supposing they occur in equal numbers in a given area, and that certain birds by chancing to catch three or four of the former in succession were induced to prey upon butterflies with that coloration, then, from a mathematical standpoint, every alternate specimen caught by any bird would be *A. echeria*. Now I think we are quite safe in assuming that the fact that every other butterfly caught had a nauseating taste and smell would be far and away more likely to create a strong and lasting impression upon a bird's mind than the fact that every second one proved to be edible,

and would be quite sufficient to deter the bird from attempting to eat butterflies of that colour. This is from a mathematical point of view solely, but, from what I know of these two forms in life, I believe that presuming them to occur in equal numbers, a larger proportion of *echeria* would actually be captured, for *minia* is a much more shy insect, and although it has the same slow sailing flight (when undisturbed) it does not keep on the wing nearly as long as *echeria*; moreover, it is much more wary and always on the alert for danger, going off at a smart pace when frightened, and not returning to the same spot as *echeria* frequently does after being struck at; altogether it is a much more difficult insect to capture. Indeed I do not see why the mimic should not even somewhat surpass the mimicked species in numbers, without upsetting their relations to one another, provided the taste of the latter be sufficiently unpleasant, and particularly if the flavour be of a *lasting* nature."

"*Malvern, May 14, 1897.*—I feel quite satisfied that *Pseudacræa trimenii* is a mimetic and not a protected species. In spite of its larger size it looks wonderfully like *Acraea acara* on the wing, and the first few examples I caught completely took me in. Their flight is like that of all *Pseudacræas* and *Euralias*—slow and sailing—so long as they are not disturbed; but if struck at and missed they are off like a shot and do not often give one a second chance. At this particular spot (*Malvern*) they are a good deal commoner than *A. acara*, which is only a rare visitor. The latter is however common on the immediate coast, where *P. trimenii* is I am told pretty plentiful in good seasons."

"*Salisbury, Jan. 12, 1901.*—I quite agree with you that the resemblance between the under-sides of *Delias pandemia* and *Isbarta pandemia* is the most remarkable case yet brought forward, and one cannot but marvel how such exact similarity can have been arrived at. Although I should certainly incline to the belief that the mimicry is Müllerian, judging by the congeners of both forms, yet its very exactitude seems to be a difficulty, for although one can readily understand how in an edible and much-persecuted species the resemblance might be brought up to so high a grade, yet it is hard to understand how this could be effected in a species which is comparatively immune from attack. For it seems to be an inevitable

deduction from the theory of mimicry that a high grade of resemblance must imply excessive persecution, either now or within recent times, unless we are prepared to admit some other convergent force."

"*Salisbury, Sept. 27, 1901.*—With regard to Müllerian mimicry I quite agree that the slow flight and the bright colours of protected forms would lay them open to much experimental tasting from inexperienced birds; but the extreme toughness of their integuments (for example in the *Acraas*) and their great vitality seem to have been specially developed to minimize this danger. And whereas the Batesian mimic, if thus experimented with, would promptly be eaten, a Müllerian butterfly would run a very good chance of surviving its injuries and propagating its kind. Do not suppose that I in any way disbelieve in the action of Müllerian mimicry, for I certainly think it must be a very strong factor. But this point seems to me to be a real difficulty, and I should like to be able to answer it satisfactorily if it were brought up by an opponent."

L. *Miscellaneous Observations on Mimicry in South African Rhopalocera.* (G. A. K. M.)

a. *Nymphalinx.*

"*Malvern, Natal; Feb. 21, 1897.*—I do not remember ever having seen it suggested that the female of the handsome *Charaxes wipharex* mimics *A. echeria*, but I have little doubt that such is the case. It is a fairly common species at the Karkloof, but difficult to catch, and I only took one. I believe there are more instances of mimicry in this genus, e.g. *achamenes* and *guderiana*, of which the females are very scarce (though the male of the former is one of the commonest *Charaxes* in Mashonaland) and very differently coloured from the males, being remarkably like the common widespread *C. saturnus*. Again, some years ago I pointed out to Trimen the strong resemblance of the female of *C. whytei* to *Neptis agatha* on the wing. I hope to be able to prove before long that *Neptis* is a distasteful genus (by the way, is *Limenitis* edible?), as its appearance and habits certainly point that way."

β. *Pierinx.*

"*Estcourt, Natal; Oct. 15, 1896.*—In Durban *Mylothris*

agathina was fairly abundant, and I was interested to notice the very close resemblance between it and *Belenois thysa*, though, as is the case with most mimics, the latter has a much quicker flight when disturbed. *B. thysa*, so far as my experience goes, is confined to the warm coast belt, whereas *M. agathina* is common everywhere throughout South-east Africa."

"*Malvern, March 12, 1897.*—It is curious to note that although *Nepheronia argia* was common at the Karkloof, I never saw a single specimen of *Mylothris agathina*. Mr. Ball has in his collection a very fine variety of the female of the former, which clearly mimics *Mylothris trimenia*, the upper-side of the hind-wings being lemon-yellow, and the red mark on the under-side of the fore-wings absent. This is the only one I have seen, although I took one or two females showing an approach towards it, one of which I send you."

"*Umkomaas Mouth, Natal; Sept. 3, 1897.*—I am afraid I can hardly bring myself yet to believe in Dixey's theory that the *Pierinæ* are for the most part protected. As regards our South African species, the only ones which I feel confident are protected are *Mylothris agathina*, *ruppellii*, and *trimenia*, and *Pontia hellica*. For the remainder I think we must find some other cause to account for their numbers and wide range. In *Terias* the larva possesses wonderfully assimilative colouring, and is extremely difficult to detect on the food-plant, and so far as the experience of Hutchinson and myself goes with *T. brigitta* we have never yet observed a single case of parasitism. The protective coloration and comparative freedom from parasites of the larva, and the protective seasonal colouring of the imago, would no doubt go a long way to explain their number, though I fancy there must be some other factor."

"*Salisbury, May 1, 1899.*—Query: are the black bands in the females of *Teracolus* acquired in mimicry of the common and widespread species, *Herpænia eriphia*?"*

γ. *Papilioninæ*.

"*Salisbury, Dec. 26, 1897.*—*Papilio brasidas* I consider

* Dr. F. A. Dixey informs me that Professor Westwood probably suspected a relationship between the markings of *H. eriphia* and *T. eris*, for he had removed a specimen of the former species from the others, and placed it next to a dry form of the *Teracolus*.

to be merely a local race of *P. leonidas*, as every one must do who has seen a long series of the two forms. I have found typical *leonidas* pretty plentifully in the low veldt of Mashonaland (Mazoe and Umfuli Rivers) and I also saw it at Delagoa Bay. I have always been struck with its marked difference in habit from the Southern *brasidas*. Its flight is strong and rapid, and it always goes straight ahead like *P. polices* and *P. antheus*, which it somewhat resembles on the wing in spite of its very different shape. *Brasidas*, on the other hand, has a slow sailing flight, going backwards and forwards over the same ground and often frequenting one spot for days. Now there is absolutely nothing suggestive of protection in the flight of *leonidas*, none of that slow sailing movement to show off its coloration which is so characteristic of the protected *Danainæ* and *Acræinæ*. Moreover, there is no Danaïne occurring south of the Zambesi which is anything like it at all, and this is very significant. I cannot therefore resist the conclusion that in this country *leonidas* is one of those unprotected species which has succeeded in the struggle for existence by its strong rapid flight, and perhaps by protection in the larval stage like *P. demodocus* and *P. corinnus*, whereas in Natal it has found it advantageous, owing to the abundance of *Amauris echeria*, to adapt its coloration in mimicry of that species by the reduction in size and number of the spots in the fore-wing and the toning down of the colour from glaucous green to greenish-white, accompanied by the marked change in its mode of flight. It does not seem to me that convergence would explain the facts, for if *leonidas* is itself protected it should exhibit throughout its range that slow flight which is the 'hall mark' of protection, which it certainly does not in Mashonaland. I believe in Central Africa it is said to mimic *T. petiverana*, and it would be most interesting to find out whether it has there assumed the Danaïne flight."

"*Malvern, Feb. 21, 1897.*—I have been collecting in the Karkloof Forest some twenty miles north of Maritzburg for the last three weeks. The only *Amauris* occurring there is *echeria*, which is very common, though not this year, which is a curiously abnormal one, and as usual the typical female of *Papilio cenea* is common, the *dominicanus*-like form occurring only very rarely. But last year, so my host Mr. Jas. Ball informs me, the latter was very abundant—quite as common as the typical one, and he

caught a long series of them. It seems clear they were not immigrants from Durban, but what caused their appearance in such unusual numbers it is difficult to understand. I may mention that in the last few years Mr. Ball has caught two *E. wahlbergi* but has never seen *dominicanus*. While there, I saw six females of *P. cenea*, two of each of the three forms."

31. WARNING COLOURS AND MIMICRY (ALMOST WHOLLY MÜLLERIAN) IN SOUTH AFRICAN COLEOPTERA.
(G. A. K. M., E. B. P.)

[In the groups described below, Coleoptera play a dominant part, either making up the whole or, except in the case of the Mutilloid group, acting as models for other insects. In this one exception the chief interest centres in the Coleoptera, and therefore the group is included here. A certain number of mimetic Coleoptera will be mentioned elsewhere in other groups which have collected round various types of Hymenopterous models.

In the present section the extraordinary predominance of Müllerian associations in South African Coleoptera stands out as the most prominent conclusion.—E. B. P.]

A. *Peculiar Warning Patterns and Directive Marks in Carabidæ and Cicindelidæ.* (E. B. P., G. A. K. M.)

Some of the warning patterns of the large *Carabidæ* of the genus *Anthia* are very remarkable and effective, and their development and relationship in the different species extremely interesting.

Six illustrative examples are figured on Plate XVII. In Fig. 21 we see the ancestral appearance, the uniform black of so many large Carabids, in *Anthia massilicata*. Mr. Marshall's account of the habits of the South African members of the genus, printed on page 510, shows that such a beetle is highly conspicuous. It is no doubt an advantage, however, to gain easily-recognizable distinctive marks on the black ground of the exposed dorsal surface, and we find that the species of *Anthia* do, as a rule, possess two or more white patches upon some part of this area. The pair of elongated thoracic white patches, in *A. petersi* (Fig. 22), are borne upon the sides of a thorax which is very like that of *massilicata*, while in *A. thoracica* (Fig. 23) this part of the body is greatly widened and the white patches

become a broad oval in shape. A pair of white spots (as well as a white line towards the outer border of the posterior half of the elytra) has also arisen on the anterior part of the elytra in *A. omoplata*, var. *mellyi* (Fig. 26), and it is of deep interest to note that these spots at a little distance or when the insect is moving would resemble the entirely different thoracic spots of *thoracica* far more closely than these latter resemble the entirely homologous spots of *petersi*. The comparison of Fig. 23 with 22 and then with 26 will bear out this conclusion. Perhaps one reason for the development of the remarkable structures in which the spots are situated in *thoracica* (they are placed in the concavities of special lateral outgrowths of the thorax) may be in order to favour the synaposematic approach to an arrangement like that of *mellyi*; for by this means it is possible for the spots to attain approximately the same size and shape, and at the same time to retain an interval between them which corresponds to that obtaining in the very different position upon the elytra. The concavities exist however in a much smaller form in *A. maxillosa*, and the white markings in them are inconspicuous.

In *A. nimrod* from West Africa (Fig. 25) we see a further development of the *mellyi* pattern in the appearance of another pair of spots on the posterior region of the elytra, while in *A. sex-guttata*, from India (Fig. 24), this appearance is combined with the two spots of *thoracica*, thus building up a warning pattern of remarkable simplicity and effectiveness, being an almost exact negative of the six of dominoes. The success of the aposeme is much enhanced by the approximate equality of the shorter intervals between the spots of each pair, and the longer ones between the spots of one pair and the corresponding spots of the next. The great breadth of the thorax permits this symmetry in one direction without the development of outgrowths like those of *thoracica*, while symmetry in the other direction has been rendered possible because the middle pair of spots occupies a more posterior position on the elytra than does the corresponding pair of *nimrod* or *mellyi*. It will be seen by a glance at Figs. 23 to 25 that the addition of the spots of Fig. 23 to the thorax of Fig. 25 would produce a very inferior warning pattern as compared with that of *sex-guttata* (Fig. 24).

Mr. Marshall gives the following account (1902) of the habits of these formidable beetles:—

"The warning character of the large spots and stripes of the *Anthias* (Plate XVII, figs. 22-26) is well borne out by the appearance of these insects in their natural haunts. They are purely terrestrial in their habits, and prefer open, treeless country, where owing to their large size and striking coloration they are very conspicuous objects. When alarmed they adopt a very characteristic warning attitude, raising themselves high on their legs, walking in a quick jerky manner and often twisting sharply from side to side; but, as in the case of other aposematic insects, when they find these demonstrations are of no avail they endeavour to make good their escape and are then capable of running at a very fair pace. Their acid secretion is very powerful, and causes a strong stinging sensation when it touches the skin of the face or the more tender parts of the hands, and as it can be projected to a distance of some four or five feet, the insect would have to be captured with considerable caution even by an enemy which might be aware of its powers. The liquid is always ejected upwards, and the insects seem capable of controlling its direction to a limited extent. A very similar warning attitude is observable in the huge Cicindelids of the genus *Mantichora*, at least I have seen it in *M. herculeana*. The habits of this insect are very similar to those of *Anthia*, but it cannot project its protective secretion, which merely exudes when it is handled; the liquid also is not acid as in *Anthia*, but possesses a strong smell."

Mr. Marshall brings forward the very probable hypothesis that the posterior white spot or spots of the small and medium-sized *Carabidæ* are directive. The fact that they form an important element in the Mutilloid appearance of these Coleoptera is no objection whatever to this hypothesis, which is explained in detail below; for it is probable that the posterior white spots of the female *Mutillidæ* may have a similar function, directing attention to the sting. Mr. Marshall states (1902) that the abdomen is the most conspicuous part of a *Mutillid* (see p. 512).

"Among the diurnal *Carabidæ* in South Africa the frequent occurrence of a conspicuous white spot at the apex of the elytra is very noticeable, and there is good ground for believing that this spot is of a directive character. Unlike such insects as *Cantharidæ*, *Lycidæ*, etc., the *Carabidæ* do not appear to possess any general distastefulness, but depend for protection solely upon their

power of squirting a strongly acid liquid from behind. In the case of the largest species, such as *Anthia*, the great strength and large quantity of this liquid render it a very efficient protection; but in the smaller species my experiments and observations lead me to suppose that this is not the case, but that the utility of the secretion lies rather in the fact that it enables the insects momentarily to disconcert their enemies, and this, owing to their great activity, gives them an opportunity to escape. Under these circumstances it is evidently of importance that an attack from an enemy should be directed to the anal portion of the body in order to ensure its receiving the discharge. The anal white patch is especially noticeable in such genera as *Polyhirma* (*semisuturata*, *bennettii* [see Appendix, pp. 547, 548], *notata*, *rutata*, *macilenta*, etc.) and *Piczia* (*marshalli* and *mashuna*); it also occurs in the Cicindelid *Myrmecoptera polyhirmoides* which consorts with many of the above species. It is probable that the two white or yellow spots which are found in so many *Carabidæ* and *Cicindelidæ* (see Plate XVII, figs. 7–11, 14–19) towards the apex of the elytra have also a similar significance, that of the *Cicindelidæ* being of course mimetic (of *Mutillidæ* and *Carabidæ*)."

B. *Mutilloid Coleoptera: Cleridæ, Carabidæ, and Cicindelidæ: Primary and Secondary Synaposematic and Pseudaposematic Associations.* (E. B. P.)

When forwarding the following mimics of *Mutillidæ*, Mr. Marshall also sent a record of habits:—

"*Salisbury, Jan. 8, 1899.*—The Mutilloid type is not uncommon among *Carabidæ*, *Eccoptyoptera cupricollis* being a beautiful instance of mimicry. But the markings are most developed among the *Cleridæ*, of which I have no less than twelve species all exhibiting the Mutilloid marking more or less distinctly; I expect they will be found to be parasitic on *Mutillidæ*. I have also caught a little spider which is an excellent Mutilloid mimic."

This species of Mutilloid spider and another sent later have been described by the Rev. O. Pickard-Cambridge, F.R.S., as *Prosthesima albomaculata* and *Titus lugens*. (Proc. Zool. Soc. Lond., 1901, p. 11, figs. 2, 3, Plate V.)

"*Salisbury, Feb. 12, 1899.*—The Mutilloid group is interesting though not so satisfactory from a cabinet point

of view, the resemblance being much less marked than in the field, except perhaps *Eccoptytera* which is a splendid case, and it has caused me to hesitate more than once before venturing to handle it. At the present time I would not venture to express an opinion as to the use or significance of the colours in this group. The *Mutillidæ* of course are armed with a powerful sting, which however they are slow to use, and besides they are very hard; the red prothorax is by no means conspicuous when they are running on the ground, the abdomen being the part that catches the eye, and when hard pressed this is elevated in the air evidently as a warning. I have noticed that it is very difficult to distinguish the pattern while the insect is running, the general impression being merely that of a black body with white spots. The same applies to the *Cicindelidæ* and *Carabidæ*, which are all fast runners and most of them very difficult to distinguish *inter se* in the field at first sight. The exact resemblance of *Graphipterus antiokanus* to *Piezia selousi* is marred by the shrinkage in the former of the pygidium, which bears two white patches. *Atractonota*, despite its markings, very much resembles one of our larger black ants, especially in its manner of running. A good many other species (especially of *Cleridæ*) might also be included in the group."

The Mutilloid group of Coleoptera from Salisbury may be arranged together with their models as follows, the plan being that adopted in Plate XVII, figs. 1-12 and 14-19:—

MUTILLIDÆ.					
Mutilla purpurata ♂ Fig. 1.	M. tettensis ♀ Fig. 2.	M. cepheus ♀ Fig. 3.	M. leucopyga? ♀ Fig. 4 (Nov. 1898— Jan. 1899).	M. sycorax ♀ Fig. 5.	M. horrida ♀ Fig. 6. (Nov. 1898— Jan. 1899).
CARABIDÆ.					CLERIDÆ.
Atractonota mulsanti Fig. 7.	Atractonota mulsanti Fig. 8.	Polyhirma enigma Fig. 9.	Polyhirma enigma Fig. 10 (Nov. 1898— Jan. 1899).	Eccoptytera cupricollis Fig. 11.	Graptoclerus, sp. Fig. 12.
CARABIDÆ.			CICINDELIDÆ.		
Graphipterus antiokanus Fig. 14 (Nov. 1898— Jan. 1899).	Piezia selousi Fig. 15.	Polyhirma bilunata, Boh. Fig. 16. (Nov. 1898— Jan. 1899).	Myrmecoptera marshalli Fig. 17.	Myrmecoptera invieta Fig. 18.	Myrmecoptera bilunata Fig. 19.

All were captured at Salisbury, in Nov. 1898, with the exception of those specially noted as taken between Nov. 1898 and Jan. 1899.

Other species are not included in the Plate for want of space. Thus *Piezia marshalli* has a single median white spot, of which half is on one elytron and half on the other, in place of the posterior well-separated pair of spots on *P. selousi*; and there are other species, outlying members of the group under discussion, in which the Mutilloid appearance becomes less marked, while in *Polyhirma semi-suturata* it fades away altogether, although this intensely black beetle, with its white dorsal line anteriorly and white patch posteriorly, seems to be very conspicuous. The appearance of the group and the relation to the outlying species suggest a strong and very complex Müllerian association. The large *Carabidæ* of the genus *Anthia* are either entirely black or possess a peculiar synaposematic appearance, described on pp. 508-510, and figured on Plate XVII, figs. 22 to 26. The smaller *Carabidæ*, depending upon a less development of the same defence—the power of discharging a strong acid secretion—have gained an appearance, due, like that common in *Anthia*, to white markings on a black ground, but arranged so as to suggest more or less strongly the likeness of a *Mutilla*. In a single species, as Mr. Marshall points out, the resemblance is extraordinarily exact (Plate XVII, fig. 11). This may be on account of habits and a mode of life which render the likeness especially beneficial. The smallest *Carabidæ*, the *Atractonota* and *Polyhirma ænigma* (Plate XVII, figs. 7-10), in shape resemble large ants, and Mr. Marshall states above that the movements of the former aid in producing this effect. On the other hand, their white spots appear to be certainly Mutilloid or perhaps rather to resemble the Mutilloid white spots of the other unant-like *Carabidæ*. Nothing is more characteristic of a Müllerian (synaposematic) group than the complexity of likeness which is thus revealed, and yet in the light of the great hypothesis which we owe to Fritz Müller it is not difficult to understand the general principles which account for its existence.

The *Carabidæ* are a powerful, specially defended group, and it is of advantage to be recognized as belonging to the group, even though it is no doubt of still greater advantage to be mistaken, as may happen at a distance,

or on a superficial view, or during rapid movement, for the still more formidable *Mutillidæ* and ants. Hence, although the smaller species of this group resemble the latter, and the larger the former, markings are nevertheless retained which serve to connect these Coleoptera together, and enable the experience gained in an attack on one of them to be of service in preventing the waste of life in many other species. For the same reason we can understand another curious inter-relationship, viz. that there is a superficial resemblance between different genera of *Carabidæ* and between *Cicindelidæ* and *Carabidæ*. Running through, but not concealing the resemblance to the Hymenoptera, is a resemblance between the Coleopterous mimics themselves. Thus there is the likeness described by Mr. Marshall on p. 512, between *Graphipterus antiokanus* and *Piezia selousi* (compare Plate XVII, figs. 14 and 15), while the remarkable likeness of the *Cicindelidæ* to the *Carabidæ* will be at once appreciated when Figs. 17, 18 and 19 are compared with 15 and 16. The same explanation is doubtless valid. The *Cicindelidæ* are less powerful than the *Carabidæ*, but many of them emit a peculiar scent, and the genus *Tricondyla* is closely mimicked in Borneo by the Locustid *Condylodera tricondylodes*. We can well understand that it is to the advantage of *Cicindelidæ* to be one with another and more powerful set of Coleoptera, even though it may be a further and probably greater advantage to resemble the *Mutillidæ*, a resemblance which is also involved in the appearance they have gained. If this explanation be sound we shall expect also to find examples of the same kind of likeness between *Cicindelidæ* and *Carabidæ* which do not resemble these Hymenoptera. Plate XVII shows that this is undoubtedly a fact, for the all-black *Polyhirma boucardi* (Fig. 13) is seen to be strongly resembled by a Cicindelid, *Myrmecoptera polyhirmoides*, var. *mashuna* (Fig. 20), belonging to the same genus as the three white-marked species figured in the same Plate.

The *Oleridæ* everywhere tend to resemble *Mutillidæ*, but they also resemble *Cantharidæ*, and more rarely *Lycidæ* and even *Coccinellidæ*, while one genus is beautifully mimicked by a Longicorn in Borneo. The first-mentioned likeness is probably a marked example of synaposematic colouring, and I should expect that the character of the original structure and warning pattern,

rather than the parasitism which Mr. Marshall suggests, rendered resemblance to *Mutillidæ* above all other specially-defended insects particularly feasible for these Coleoptera. A good example of such mimicry is seen in Plate XVII, fig. 12, representing *Graptoclerus*, sp.

I believe that the principles discovered by F. A. Dixey, which are here employed to explain the curiously complex inter-relationships of Mr. Marshall's Mutilloid group, will hereafter be found to have an important bearing upon many superficial resemblances of mimicry and common warning colours in all countries, and in many orders of insects and probably other animals.

The double (or treble, etc.) resemblances which may be perceived one underlying the other in the appearance of a single form may be conveniently spoken of as Primary, Secondary, Tertiary, etc., Common Warning Colours (Proto-, Deutero-, Tritosynaposematic Resemblance), or as Primary, Secondary, Tertiary, etc., Mimicry (Proto-, Deutero-, Tritopseudaposematic Resemblance). Thus the resemblance of the *Atractonota* to an ant, or of *Myrmecoptera* to a Mutillid is Protosynaposematic, while their resemblance to the Carabid genera *Polyhirma*, *Piczia*, etc., is deuterosynaposematic. On the other hand, the resemblance of the black *Myrmecoptera* to *Polyhirma boucardi* is protosynaposematic, or rather, synaposematic, since there appears to be no other underlying or overlying resemblance in this case.

Many examples of this kind will be found in the section on Mimicry in Lepidoptera; see especially pp. 470, 471, 485-487.

I must here again refer to Dr. F. A. Dixey's important memoirs, alluded to in greater detail on p. 502, as containing the first account and interpretation of the extremely complex inter-relationships which may exist in Müllerian associations. The principles which he laid down are here found to supply the interpretation of many puzzling and subtle relationships, not only among Lepidoptera, but also in other Orders in which the phenomena of mimicry, warning colours, etc., have been far less fully investigated.

C. Lycidæ as Models for other Coleoptera and Insects of many Orders. (G. A. K. M.)

[The splendid and complex convergent group, represented on Plate XVIII, figs. 1-52, is by far the most

complete illustration hitherto known of the power of mimicry to attract forms of all kinds irrespective of affinity. It is of the deepest interest to observe that the association is almost entirely Müllerian (synaposematic). The following passages are quoted from letters written by Mr. Marshall about the time when the first consignments were sent; but the group became very much larger when the additions of later consignments were included.—E. B. P.]

Salisbury, Jan. 8, 1899.—The two most prominent types of colour among mimetic Coleoptera are what I call the Lycoid and Mutilloid types. Of the former I have put aside for you a series comprising fifteen species, including several species of *Lycus*, three species of Longicorns, a Reduviid bug, a fly, a wasp, an Arctiid moth, a *Mylabris*, a *Hyperacantha*, etc., and I shall be able to add more in all probability.

The Lycoid Arctiid moth is a day-flyer, but the deceptive resemblance is not good on the wing, being best shown when the moth sits, as is its wont, on the ends of grass-stems, etc., after the manner of a *Lycus*; it is perhaps even more like *Prionocerus dimidiatus*, a Lycoid unpalatable Malacoderm which has a similar habit.

Salisbury, Feb. 12, 1899.—The six species of *Lycus*, the *Prionocerus*, *Diacantha*, *Zonitis*, *Mylabris*, and *Eletica*, I proved by experiment to be distasteful to baboons and a kestrel. The Zygænid I presume to be so likewise, as it emits a strong smell; the *Telephorus* will also probably prove to be unpalatable. The four species of wasps have all got very effective stings; thus the only unprotected insects are the fly, which is an admirable mimic of one of the wasps, and the three Longicorns, though I am not quite certain about *Philagethes*. As to the *Reduvius* I do not know what to say, there are certainly some very remarkable cases of mimicry in this family. * * * *
In flight the Zygænid [*Neurosymploca*, Fig. 52] is aided by its very brilliant hind-wings, and the Hymenoptera have a flight very different from, and far swifter than, that of *Lycus*.

[A complete list of the species arranged in their respective families is given below. Large as the group is it could certainly be made much larger, especially if the whole of South Africa were put under contribution. Thus an obvious addition to the Longicorn mimics is *Dyemen-*

nus apicalis, which Mr. Marshall has not yet taken in Mashonaland.—E. B. P.]

GROUP WITH LYCOID MARKINGS (Plate XVIII, figs. 1–52).

COLEOPTERA	<i>Copridæ</i>	Aphodius holubi (fig. 18). Lycus (Merolyceus) rostratus (figs. 1, 2). Lycus (Acantholyceus) constrictus (fig. 3). Lycus ampliatus (figs. 4, 5).
	<i>Malacodermata</i>	Lycus (Lopholyceus) zonatus (fig. 6). Lycus (Lopholyceus) haagi (figs. 7, 8). Lycus (Chlamidolyceus) subtrabeatus (figs. 9, 10). Lycocerus mimicus (figs. 11, 12). Prionocerus dimidiatus (fig. 13).
	<i>Melyridæ</i>	Pœcilomorpha fasciaticollis (fig. 14);
	<i>Phytophagæ</i>	Diacantha conifera (figs. 16, 17). Peploptera zambesiana (fig. 15).
	<i>Laagriidæ</i>	Eutrapela sp. (fig. 19).
	<i>Cantharidæ</i>	Eletica rufa (figs. 20, 21); Mylabris palliata (fig. 22); Zonitis sp. (fig. 23). Amphidesmus analis (fig. 25); Philagathes letus (figs. 26, 27). Nitocris sp. (fig. 28); N. similis (fig. 30); N. ?nigricornis (fig. 29). Blepisanis haroldi (fig. 24).
	<i>Longicornia</i>	Phanomeris sp. (figs. 44, 45); Iphiaulax bicolor (fig. 46); Bracon luctuosus (fig. 47); Bracon ?luctuosus (fig. 48).
	<i>Braconidæ</i>	Pompilus morosus (fig. 36); P. capensis (fig. 37); P. diversus (fig. 38); P. vindex (fig. 39).
	<i>Pompilidæ</i>	Cerceris orientalis, var. (fig. 40). Notogonia cœsus (fig. 41).
	<i>Crabronidæ</i>	Rhynchium radiale (fig. 42); R. rubens (fig. 43).
	<i>Larridæ</i>	Serimetha mutilata (fig. 33).
	<i>Eumenidæ</i>	Lygaeus furcatus (fig. 34); Oncopeltus fumeus, var. jucundus (fig. 35).
HYMENOPTERA	<i>Pyrhocoridae</i>	Vitumnus miniatus (fig. 32); V. cinabarinus (fig. 31).
	<i>Lygæidæ</i>	Ilema elegans (fig. 50).
HEMIPTERA	<i>Reduviidæ</i>	Neurosymploca ochreipennis (fig. 52); Zygenid (genus ?) (fig. 51).
	<i>Arctiidæ</i>	Xiphocerus cruciger (fig. 49).
LEPIDOPTERA	<i>Zyganidæ</i>	
DIPTERA	<i>Asilidæ</i>	

In the above group the beetles of the genus *Lycus* undoubtedly constitute the dominant factor towards which the other insects have converged with more or less exactness. The members of this genus are very numerous throughout S.E. Africa both in species and in individuals. They are most conspicuous insects, and the majority of them occur on flowers, though a few species are more often

to be found on the heads of grasses. In habits they are very sluggish and have a slow heavy flight; when handled they usually emit from their limbs a very strong-smelling white liquid, and they frequently feign death. The Melyrid *Prionocerus* has somewhat similar characteristics, but is found only feeding on grass seeds. Among the Phytophaga it is possible that the *Pœcilomorpha* is a Batesian mimic, for the species of this genus are nearly all more or less scarce, and moreover exhibit marked mimetic tendencies in very different directions. The *Diacantha*, to which *D. dimidiata* might also have been added, is a very plentiful insect with a nauseous smell; it causes much damage to garden plants such as cucumbers and pumpkins. The *Peplotera* is likewise abundant, frequenting acacias. All the species of Lagriadæ and Cantharidæ mentioned are flower-feeders, and are certainly protected by distasteful qualities. The significance of the colouring in the Longicorns is still a matter of doubt, as I have obtained no experimental evidence with regard to them; probably most of them are pseudaposematic, but *Philagathes* may be a Müllerian mimic. Of the Hymenoptera the quick-flying *Notogonia* is the only scarce species with us; the other Aculeates all visit flowers more or less commonly. The Braconids are slow and very conspicuous fliers, being evidently protected by their very strong smell. The species of Hemiptera also occur commonly on low plants and bushes; the position of the Reduviids is not quite certain, as experimental proofs are lacking. The Asilid fly appears to be a very rare species and is doubtless a Batesian mimic.

D. *Müllerian (Synaposematic) Groups in South African Coleoptera.* (G. A. K. M.)

a. *Cantharid Group* (Represented on Plate XIX).

COLEOPTERA	<i>Cantharidæ</i>	{	<i>Mylabris dicineta</i> (fig. 1); <i>M. tettensis</i> (figs. 2-3); <i>M. tricolor</i> (fig. 4); <i>M. oculata</i> (figs. 5, 6, 13); <i>M. holosericea</i> (fig. 9); <i>Actenodia chrysomelina</i> (figs. 7, 8, 11); <i>Decatoma lunata</i> (figs. 10, 12).
	<i>Longicornia</i>		
HEMIPTERA	<i>Phytophaga</i>	{	<i>Cymatura bifasciata</i> (fig. 14); <i>Ceroplesis caller</i> (fig. 15); <i>Anubis mellyi</i> (fig. 16). <i>Clythra wahlbergi</i> (fig. 20). <i>Oncopeltus fanelicus</i> (fig. 17).
	<i>Lygwidæ</i>		

The same species is sometimes repeated two or even three times in the Plate in order to show common variations in the pattern.

All the species of Cantharidæ in this group are abundant in Salisbury, some of them occurring in such numbers as to form a serious pest in the local flower-gardens. All those mentioned feed on flowers exclusively, except *M. holosericea* which seems to be more attached to grasses. In every case they emit a quantity of vesicating yellow juice from the antennæ and joints of the legs when handled, and also eject a liquid from their mouths; their flight is heavy and noisy, and they are most conspicuous insects in every way. *Ceropalesis caffer* is probably the commonest Longicorn in South Africa, attacking dead wood of almost any description, but particularly frequenting acacias. It has a slow conspicuous flight, and has been proved by experiment to possess distasteful qualities, though I have not noticed that it gives off any smell.

The Longicorn *Cymatura bifasciata* is specially attached to a species of *Lantana*, which grows to a fair-sized bush, and the insects occasionally may be found on it in some numbers. It is certainly a Müllerian mimic, as it has a strong smell, is very sluggish, and feigns death persistently when captured. It was refused with evident dislike by baboons. *Anubis mellyi* does not occur at Salisbury, but is fairly common at Umtali, further east, where it frequents the flowers of low plants. It is a brightly-coloured insect, and emits the strong characteristic smell of the diurnal Cerambycidæ.

β. *Intermediate Group connecting the Cantharid and Coccinelloid Groups* (Represented on Plate XIX).

COLEOPTERA	Cantharidæ	{	Actenodia chrysomelina (figs. 7, 8, 11).
	Phytophaga		Melitonoma sp. nov. (fig. 18); M. truncatifrons (fig. 19); M. litigiosa (fig. 21); M. epistomalis (fig. 23); Antipus rufus (figs. 22, 25); Clythra lacordairei (fig. 24); Aulacophora festiva (fig. 26); Cryptocephalus 5-plagiatus (fig. 27); C. varioplagiatus (fig. 28); Syagrus marshalli (fig. 29).

This group merges very gradually into the Mylabroid group on one hand, especially in those species where the rows of spots coalesce into transverse bands, and at the

other end of the series it converges to the Coccinelloid type, particularly in the *Cryptocephali*. The association is probably of a purely Müllerian character so far as the species mentioned are concerned. They all have very similar habits, occurring on low plants and flowers, and making no attempt at concealment. *A. festiva* is much more plentiful than the others, and is probably the dominant member of the group.

γ. *Coccinelloid Group* (Represented on Plate XIX).

COLEOPTERA	<i>Coccinellidae</i>	{ <i>Epilachna dregei</i> (figs. 40, 41); <i>Chilomenes lunata</i> (fig. 42).
HEMIPTERA	<i>Pentatomidae</i>	
		<i>Steganocerus multipunctatus</i> (fig. 39).

I have frequently found all these three species occurring together on the flowers of a *Lantana*, and as they are all common, conspicuous, and strong-smelling insects, the group is undoubtedly synaposematic.

δ. *Group of small pale yellow and red Phytophaga with their Melyrid and Curculionid Mimics.* (E. B. P.)

With respect to a series of nine small brightly-coloured Coleoptera of about the same size (with the exception of *Urodactylus*, ? sp. ♀, which is conspicuously smaller than any of the others), Mr. Marshall wrote that he should be unwilling to hazard an opinion. It appears tolerably clear however that they form a beautiful Müllerian group, including perhaps a single Batesian mimic. All were captured at Salisbury, and, with the two exceptions noted below, in January 1899. The species are arranged below as they are on Plate XIX, where each is represented twice the natural size.

PHYTOPHAGA.

<i>Platyxantha</i> <i>bicincta</i> fig. 30.	<i>Gynandrophthalma</i> <i>posticalis</i> [or closely allied, M. Jacoby] (Feb. 1899) fig. 31.	<i>Monolepta</i> <i>vineta</i> [or closely allied, M. Jacoby] fig. 32.
<i>Crioceris</i> <i>coronata</i> , Baly (= <i>balyi</i> , Harold) fig. 33.	<i>Paralepta</i> <i>ornata</i> fig. 34.	<i>Asbecesta</i> <i>ornata</i> fig. 35.

MELYRIDÆ.

Urodactylus, sp. ♂
fig. 36.

Urodactylus, sp. ♀
fig. 37.

CURCULIONIDÆ.

Apoderus
gentilis
(Nov. 1898)
fig. 38.

The group consists of pale yellow insects with bright red anterior section, made up by thorax and head, of which the eyes only are black in some of the species, although in others black markings extend over a variable proportion of the cephalic surface. The elytra are crossed transversely by a black band at the base, and another at the junction of the third and posterior fourth of their length. In some species the anterior band, in others the posterior is reduced to two more or less widely-separated spots or patches. In the species of *Crioceris*, the anterior band is represented by four small black spots, two on each elytron. In the *Urodactyli*, the posterior band is represented by a semi-circular black mark with the concavity directed posteriorly on each elytron.

In spite of the variation in detail the species would produce the same effect at a little distance, and there can be no doubt about the interpretation of the whole as a synaposematic combination with the *Curculio* as a doubtful pseudaposematic member. Mr. Marshall states that there are many other species of about the same size which adopt the same warning pattern, including at least four additional species of *Melyridæ*.

Certain members of this group are very abundant and conspicuous in the spring months upon the Mosasa-tree (*Brachystegia* sp.).

E. *Comparison between certain Coleopterous Groups in Borneo and South Africa, with respect to Mimicry, Common Warning Colours, etc.* (G. A. K. M.)

[The following interesting comparison between the phenomena of mimicry and common warning colours in certain Coleopterous groups in Borneo and South Africa respectively, was made upon the receipt of a set of photographs of the material of Mr. Shelford's paper now being published by the Zoological Society.—E. B. P.]

Salisbury, Jan. 11, 1901.—I should be interested to know whether Shelford has proved the *Anthribidæ* to be

distasteful; from my knowledge of our fairly numerous South African species I should be much inclined to doubt it, as their colouring appears to be, without exception, protective, generally resembling bark or lichen; and although there are somewhat similarly-coloured Longicorns which frequent such surroundings, I should certainly class their colours as syncryptic. A somewhat similar criticism suggests itself with regard to the *Brenthidæ*, although I feel diffident in stating it, as the family is so very limited here. I know of only four species in Salisbury, all of which are sub-cortical and nocturnal in their habits, of comparatively rare occurrence, and of dull colouring. On the other hand, I have observed that the great majority of our smaller Lamiids adopt the forward position of the antennæ, which I have always regarded as procryptic, as there can be no doubt that it renders them much less conspicuous than if the antennæ were held out at an angle to the twig on which the insect sits. The procryptic nature of the position is well illustrated in the small and very elongate Longicorns *Hyllisia* and *Hippopsicon*, of which we have a few species, all of which frequent grass-stems in marshy places; they also have the elytra bifurcated, and this seems to be a common occurrence in all very elongate beetles. The Endomychid groups are very interesting. Unfortunately this family is extremely poorly represented here—only some three or four species, though the *Erotylidæ* are fairly numerous. In this latter the pattern with four yellow or reddish blotches on a black ground occurs also with us, and the insects are probably distasteful, judging by the extremely pungent smell emitted by the large *Encaustes*. Curiously enough, just after getting your photographs I found under bark a large Endomychid (new to me) of this pattern, and with it occurred an admirable mimic, a Carabid *Thyreopterus flavosignatus* (Dej.). There is another Carabid *Arsinoë fraterna* (Pér.), also sub-cortical, which mimics it closely, but unfortunately I have no specimens now; I caught only two here six years ago.

F. *Note on Rhynchophora with Procryptic Colouring as Models for Mimicry.* (E. B. P.)

Dr. A. R. Wallace has always thought that the extreme hardness of the mimicked *Curculionidæ* and *Anthribidæ*

is the character which protects them ("Essays on Natural Selection," 1875, p. 94). In answer to a letter in which I drew his attention to Mr. Marshall's record of a large *Curculio* found in the crop of a guinea-fowl (see p. 350), he wrote, Feb. 5, 1901, "The large Malayan *Anthribidae* are *intensely* hard. The guinea-fowl proves nothing, as these beetles are almost all *arborcal*, and their chief enemies are *smaller* birds. Their protective colours may save them from the *larger* insectivorous birds, their hardness from the smaller." The mimicry of Malayan *Curculionidae*, *Anthribidae*, and *Brenthidae* by Longicorns cannot be doubted. The cases are too numerous and the details of the resemblance too precise to admit of any other explanation. In South Africa, on the other hand, Mr. Marshall shows that only the first group is mimicked, and of this he has sent me a very beautiful example. Experiments are greatly wanted, especially in Borneo, where all three groups abound. In addition to their hardness Mr. Shelford shows that the larger Bornean *Curculios* are defended by their great strength; they can even cause intense pain to man by clasping the fingers with their legs and digging the proboscis into the flesh. Such defences as hardness and strength depend for their success on the size of enemies; for even hardness could not avail against an enemy large enough to swallow the beetle whole, so that it could be ground down in the gizzard, or the interior slowly extracted by digestive fluids gaining access by the joints and other apertures. Defence by a sting, a nauseous taste or smell, or unwholesome qualities, is effective against enemies of all sizes and all degrees of strength, although failing against occasional specially-adapted foes. It is possible that these considerations may enable us to understand why it is that certain *Rhynchophora* are remarkable among Coleoptera for combining a cryptic colouring with sufficient immunity to render them feasible models for mimicry. The ordinary methods of active defence among vertebrates—the power of biting or pecking, of kicking or tearing with hoofs or claws—together with the passive resistance of a spiny or hard external covering, are almost invariably associated with cryptic colouring and modes of life favouring concealment. The probable explanation is that all such methods of defence must fail before large and important classes of still stronger enemies or foes with cunning sufficient to circumvent the passive

defence. Such enemies are numerous enough and deadly enough to make the increased danger of a conspicuous appearance far greater than any advantage gained by the warning off of smaller and weaker animals. Such a defence as that of the skunk, on the other hand, appeals to enemies of many classes, and is quite independent of strength or size. Here and there special animals, probably powerful birds with deficient sense of smell, can endure the defensive odour, and to these the skunk would be an easy prey; but on the whole the increased danger of a conspicuous appearance and slow movements is far more than compensated by the warning off of an immense number of would-be enemies. Cases like that of the skunk are very common among insects, while those of active defence are very rare. Even the passive defence of a spiny or hairy covering is very different from that ordinarily adopted among vertebrates, because in the insect the hairs and spines are themselves a cause of unpalatability, and often of intense irritation, so that they tend to be associated with an aposematic appearance. It is, however, probable that the intensely hard Rhynchophora with a cryptic appearance, and especially the largest and most powerful *Curculionidæ*, are strictly comparable with the large number of vertebrates which also unite the methods of concealment with very efficient modes of active or passive resistance. Certain of the largest *Curculionidæ* possessing red marks on a black ground appear to possess an aposematic appearance, and these may be distasteful, although the conspicuous appearance may only indicate an excessive hardness and thickness of chitin which, coupled with the great size, may be a most efficient defence against a majority of enemies. Mr. Marshall tells me that the largest South African Curculios of the genus *Brachycerus*, such as *B. apterus*, are purely terrestrial, move slowly, and freely expose themselves, like our European distasteful species of Phytophagous *Timarcha*. Under these circumstances the intense black ground-colour and red spots of *B. apterus* must render it remarkably conspicuous, and it would be of great interest to ascertain, by a number of experiments on many insect-eaters, whether so pronounced an aposeme may indicate hardness alone or hardness combined with some other special protection.

The small size of the *Brenthidæ* renders it improbable

that hardness alone can be sufficient protection to the mimicked species, such as the Bornean *Diurus furcillatus*, and we are led to suspect the existence of unpalatability. In the cabinet the specimens seem to be markedly cryptic, but Mr. Shelford assures me that they are very commonly found on flowers, where their dull dark colours would be most conspicuous. Above all things experiments with insect-eating animals are greatly needed to throw light on this most puzzling and exceptional occurrence, viz. the existence of large numbers of models for mimicry among Rhynchophora with an apparent, and certainly in many cases an actual cryptic appearance.

32. COMMON WARNING COLOURS IN SOUTH AFRICAN HYMENOPTERA AND THE MIMICRY OF THEM BY INSECTS OF OTHER ORDERS. (G. A. K. M.)

A. Group with Black Bodies and Dark Blue Wings, chiefly *Possores*.

HYMENOPTERA	<i>Apidæ</i> (Pl. XXI)	{	<i>Xylocopa hottentota</i> (fig. 18); <i>X. carinata</i> (fig. 19).
	<i>Eumenidæ</i> (Pl. XXI)	{	<i>Eumenes tinctor</i> (figs. 14, 15); <i>E. dyschera</i> (figs. 16, 17).
			<i>Sphex bohemani</i> (figs. 1, 2); <i>S. cyani-ventris</i> (fig. 3).
			<i>S. pelopeiformis</i> (figs. 4, 5); <i>S. xanthocerus</i> (fig. 6).
	<i>Sphegidae</i> (Pl. XXI)	{	<i>S. umbrosus</i> (fig. 7); <i>Sceliphron chalybæum</i> (fig. 8).
			<i>Tachytes natalensis</i> (figs. 9, 10); <i>Ammophila ludovicus</i> (figs. 11, 12).
			<i>A. beniniensis</i> (fig. 13).
			<i>Salix atropos</i> (fig. 14); <i>S. vindex</i> (fig. 15).
	<i>Pompilidæ</i> (Pl. XX)	{	<i>S. dedjax</i> (fig. 16); <i>S. regina</i> (fig. 17); <i>S. obscurus</i> (fig. 18).
			<i>Pompilus sepulchralis</i> (fig. 19); <i>P. frustatus</i> (fig. 20).
			<i>Elis lachesis</i> (fig. 3); <i>E. fasciatipennis</i> (figs. 4, 5).
	<i>Scoliadæ</i> (Pl. XX)	{	<i>Scolia alaris</i> (figs. 6, 7, 8); <i>S. fraterna</i> (figs. 9, 10).
			<i>S. cyanea</i> (figs. 11, 12); <i>S. affinis</i> (fig. 13).
	<i>Tiphidæ</i>		<i>Tiphia rugosa</i> (Pl. XX, fig. 2).
	<i>Mutillidæ</i>		<i>Mutilla atropos</i> (Pl. XX, fig. 1).

COLEOPTERA (Pl. XXI)	{	<i>Cetoniidæ</i>	{	Trymodera aterrima (fig. 22).
		<i>Cantharidæ</i>		Epicauta pectoralis (fig. 23); E. subcoriacea (fig. 24).
DIPTERA	{	<i>Asilidæ</i> (Pl. XXI)	{	E. celestina (fig. 25); Lytta mœsta (fig. 27).
		<i>Bombilidæ</i>		Laparus sp. (fig. 20); L. ? tabidus (fig. 21).
		<i>Tabanidæ</i>		Exoprosopa umbrosa (Pl. XX, fig. 22).
		<i>Tachinidæ</i>		Tabanus ? biguttatus (Pl. XX, fig. 24).
HEMIPTERA (Pl. XX)	{	<i>Reduviidæ</i>	{	Orectocera (Paraphania) diabolus (Pl. XX, figs. 21, 23).
				Reduvius sp. (fig. 26); Harpactor tristis (fig. 27).
LEPIDOPTERA		<i>Zygænidæ</i>		Tascia homochroa (Pl. XX, fig. 25).

Among the Mashonaland Hymenoptera the most dominant and conspicuous group is certainly that which comprises the species having a generally black coloration with more or less metallic purple wings; for not only is the number of component species a large one, but the individuals are likewise very numerous, since the group contains many of our commonest large Aculeates, such as *Eumenes tinctor*, *Salix vindex*, *Scolia cyanea*, etc. All of the species of this large group, which are figured in Plates XX and XXI, commonly visit flowers, and owing to the numbers in which they often occur, and their close inter-resemblance, it is very difficult for one who is not an expert to distinguish the species without examining them in the net. The Scolias are the heaviest and slowest flying species of the group, though the largest Pompilids run them close in this respect, being very conspicuous both on the wing and when settled, and it seems probable that these two types constitute the nucleus of the mimetic group towards which the other genera have converged. Moreover, several of the large species of *Salix* (*Mygimima*) advertise their offensive qualities by their loud, rattling flight, which can be heard at a considerable distance. This is specially noticeable in *S. vindex*, which sounds as though it were going by clockwork, the noise often attracting one's attention when the insect is flying high above the trees. Among the other species the *Eumenes* also fly somewhat leisurely, and are not readily disturbed when feeding. But the species of *Sphex* and *Tachytes* are very active, restless insects with a swift, dodging flight. Of the Coleoptera coming into this group, *Trymodera aterrima* is the only flower-feeding species, occurring chiefly on *Protea*, the flowers of which are much frequented by Hymenoptera.

Lytta moesta and all the species of *Epicauta* are purely terrestrial in their habits, all being very common insects and evidently protected by their vesicating properties. The blue-winged Pompilids when running on the ground bear a distinct general resemblance to these insects. Of the five species of dark-winged flies, *Exoprosopa umbrosa* is the only one which visits flowers, and this has a rapid flight. The two *Lapari* and *Orectocera* (*Paraphania*) *diabolus* are to be found settling conspicuously on low plants, and have a comparatively slow flight. *Tabanus biguttatus* is a rapid flier, with the usual habits of the genus. The Zygenid moth, *Tuscia homochroa*, is a very common species; it is occasionally seen on flowers, but is more frequently observed settling in a conspicuous manner on shrubs and plants. It is very sluggish in habits and emits a strong-smelling liquid when crushed.

B. *Mimicry of Diploptera by Fossores and Insects of other Orders.* (E. B. P.)

The dominant members of the group described above are evidently the Fossores, the Diploptera and Anthophila being represented by only two species each.

It is therefore somewhat surprising to note that in one of the Scolias (Figs. 6, 7, 8, Plate XX), evident mimicry of Diploptera has been brought about in a very interesting way. The outer parts of both wings, except the costal area of the fore-wing, have become extremely transparent and invisible, possessing a peculiarly illusive quality probably due to approximation of the refractive index to that of air. The effect is that both in flight (Figs. 6, 8) and at rest (Fig. 7) the resemblance to the much narrower wings of Diploptera is most striking. The resting resemblance is peculiarly interesting, for the dark areas of the wings exactly resemble the narrow longitudinally-folded organs of the Diploptera, as may be seen by comparing Fig. 7 on Plate XX with 17 on Plate XXI, or 11 and 13 on Plate XXII, while the transparent portions of the Scolia, although in two layers (compare Figs. 1, 4, 10, etc., on Plate XX), are not seen. The transparency is well shown in Fig. 8, Plate XX, where the dark apex of the wing of *Scolia fraterna* was made to underlie the transparent part of that of *Scolia alaris*, when the photograph was taken for the preparation of the plate. The underlying wing loses

neither its sharpness of outline nor, in a print prepared from the negative, any of the detail of the surface. A tendency in the same direction is manifest in *Elis fasci-atipennis* (Fig. 5), but it is hardly noticeable in the representation of the resting position in Fig. 4. Mr. Marshall informs me that the Diplopterous appearance of *Scolia alaris* is very marked during life, both at rest and in flight.

It is interesting to inquire for the possible reason of this mimicry. Fabre ("Insect Life," translation, London, 1901, pp. 99, 100) states that the Fossores, using their sting for hunting and providing food for the larvæ, are much less prone to employ it in defence than the Diploptera, in which it has this latter meaning alone, and not only so, but when used it is far less painful in the former than the latter. The *Pompilidæ*, he considers, produce the most painful effect, but far less than those which follow from the sting of a bee. On the other hand, my assistant, Mr. A. H. Hamm, who has had great experience of our British Aculeates, and always takes them out of the net with his fingers, thus gaining very exceptional knowledge of their relative powers in this respect, does not altogether share Fabre's opinion. He states that while the common wasp, and of course the hornet, for his experience includes even this insect, produce more pain than any other British Aculeate (I leave the hive-bee out of account), many of the Fossores produce more pain and use their sting more readily than other Aculeates. At the same time Mr. Hamm's treatment is one that the mildest Aculeate may be expected to resent if its sting can pierce the skin of the fingers, and the question is rather whether the Diploptera are not recognized as more formidable than the Fossores by the natural enemies of insects. It is very probable that this is the case, the combined attack made upon enemies incautiously disturbing a society being one element in producing an increased respect for single individuals of the same kind or with the same general appearance.

When an illustration of *Scolia alaris* was shown to the Entomological Society on March 5, 1902, and this interpretation suggested, Colonel Yerbury and Mr. Verrall pointed out, at the close of the meeting, that similar opacity of the costal area of the wing and transparency in other parts was characteristic of many Diptera mimetic of Hymenoptera,

and might have a similar meaning. Mr. A. J. Chitty also suggested that the same interpretation applies to the Sesiid moth shown on Plate XXII, figs. 15, 16. In this latter case the shape of the opaque area would present during flight a very close approximation to the outline of the narrow fore-wing and small hind-wing of the *Diploptera*, many of which are figured on the same plate as the Sesiid (compare Figs. 7, 8, 10, 12, etc., with Fig. 16).

It seems probable that the case of *Scolia alaris* will throw much light on the manner in which the mimicry of *Aculeates* is brought about in insects of many orders.

*C. Group with Black Bodies and Yellow Tails, chiefly
Diploptera (Represented on Plate XXII).*

HYMENOPTERA.

Scoliadæ.
Scolia erythropyga (figs.
1, 2).
Pompilidæ.
Salius tamisieri (figs. 3, 4).
,, *spectrum* (fig. 5).

Eumenidæ.
Rhynchium synagro-
ides (fig. 6).
Synagris abyssinica
(fig. 7).
Synagris mirabilis (fig.
8).
Synagris emarginata
(figs. 9, 13).
Synagris analis (figs.
10, 11).
Synagris xanthura (fig.
12).
Eumenes dyschera
(fig. 14).

LEPIDOPTERA.

Sesiadæ.
Trochilium sp. (figs.
15, 16).

DIPTERA.

Bombylius sp. nov.
(fig. 17).
Silvius pertusus (fig.
18).

All the Hymenoptera in this group are common insects occurring in some numbers on suitable flowers. Their metallic blue wings and yellow tails make them very noticeable objects, and their flight is leisurely. Of the *Trochilium* only two specimens were taken—both of them on the wing, when the resemblance to a large *Synagris* was most remarkable, being much heightened by the transparent edging of the hind-wing, which is thus made to appear of about the same size and shape as that of the wasp. Of the two Diptera, one, the *Bombylius*, is very common, especially about flowers; the other, *Silvius pertusus*, is apparently scarce. There is not sufficient evidence to judge on their true relation to the group.

[The conspicuous yellow apex of the abdomen probably acts as an easily seen directive mark indicating the sting. Compare pages 510 to 512.—E. B. P.]

D. *Group with Dark Bodies, Central White Patch and Red-Brown Tails: Megachile the Models* (Represented on Plate XXI).

HYMENOPTERA.

Megachile chrysorrhœa (fig. 29).

„ *basalis* (fig. 28).

Cœlioxyx pusilla (fig. 30).

DIPTERA.

Laphria nr. *flavipes* (fig. 31).

The *Megachile* bees mentioned above are both common, not only visiting flowers, but also, during the drier months, occurring in some numbers on damp sand or mud near water. The parasitic *Cœlioxyx* may be seen with them in both stations, but is a much scarcer insect. The Asilid is also an uncommon species, having the usual habits of its congeners and settling about on low plants.

E. *Group with Black Thorax and Yellow Abdomen: all Hymenoptera* (Represented on Plate XXIII).

Tenthredinidæ *Athalia bicolor* (fig. 11).

Chalcididæ *Chalcis bicolor* (fig. 10).

Scoliadæ *Elis aureola* (fig. 1).

Crabronidæ { *Philanthus fuscipennis* (fig. 2); *P. diadema* (figs. 3, 4);
 P. bucephalus (fig. 5).

Eumenidæ *Rhynchium radiale* (fig. 6); *R. rubens* (figs. 7, 8).

Andrenidæ *Sphecodes rufiventris* (fig. 9).

This is a beautifully compact and uniform little group, and is specially interesting owing to its comprising species of no less than six families of Hymenoptera, which exhibit great differences in their food and general habits—especially in their earlier stages. Yet the imagines may be frequently observed all flying together about the same patch of flowers, and the uniformity of their coloration is then very striking. All the species are common and efficiently protected, so that the association is probably Müllerian.

F. *Group with Black Bodies, Blue Wings, and Yellow or Red Thorax* (Represented on Plate XXIII).

HYMENOPTERA	{ <i>Apidæ</i>	{ Xylocopa lateritia (fig. 12); X. flavo- rufa (fig. 13). Xylocopa olivacea (fig. 16); X. modesta (fig. 17). Podalirius acraënsis (fig. 14); Antho- phora ? basalis (fig. 15). Elis cælebs (fig. 18). Melittia sp. (fig. 19).
LEPIDOPTERA	{ <i>Scoliadæ</i> <i>Sciadæ</i>	

This group forms another interesting illustration of the way in which the larger mimetic groups tend to merge one into the other. Such species as the *Podalirius* and *X. olivacea* in which the anterior yellow is largely developed clearly belong to the outlying portions of the Lycoid group (Plate XVIII), whereas *Elis caelebs* has more affinity with the succeeding group; and this latter again merges away into the great black group with blue wings (Plates XX and XXI). The two largest *Xylocopas* (*X. lateritia* and *X. flavornufa*) only belong to the outskirts of the association, as the red of the thorax is in them of a much darker tint and does not show up well in the Plate. All the Hymenoptera of the group are found plentifully on flowers; but as regards the *Melittia*, the specimen figured is, I believe, the only one known.

G. Group with Black Bodies, Blue Wings, and Red or Yellow Heads (Represented on Plate XXIII).

HYMENOPTERA	{	<i>Pompilidæ</i>	{	Pompilus marshalli (fig. 20); P. dichrous (figs. 21, 22); P. anticus (fig. 24).
				Pompilus lascivus (fig. 23); Salix tamisieri (fig. 25).
COLEOPTERA	{	<i>Sphægidæ</i>	{	Tachysphex fluctuatus (fig. 26).
		<i>Longicornia</i>		Jonthodes sculptilis (fig. 28).
DIPTERA				Bromophila caffra (fig. 27).

Converging towards these but with black wings instead of blue are the Braconid *Iphiaulax ruber* (Fig. 31) and the Cantharid *Eletica rufa*, var. (Fig. 29).

This is only a subdivision of the group of black-bodied and blue-winged insects. The Hymenoptera have all much the same habits as the species contained in that group, though they are mostly of much smaller size. The Longicorn *Jonthodes* bears a very good general resemblance to the blue-winged, yellow-legged *Salix dedjax*, owing to its blue elytra and yellow legs; it is not a particularly common species, being diurnal and arboreal in its habits. It possesses a strong scent-like smell, and the mimicry is probably Müllerian. The *Bromophila* fly is very plentiful; it is the most sluggish fly known to me, and settles about on trees and bushes in a very conspicuous manner. It ejects a yellow liquid from the mouth when handled, and was refused when offered to my baboons and *Cercopithecus* monkey.

H. *Group with Black and Yellow-Banded Bodies: all Hymenoptera* (Represented on Plate XXIII).

Scoliadæ.
Myzine capitata
(fig. 35).

Pompilidæ.
Pompilus festivus
(fig. 34).

Ichneumonidæ.
Metopius discolor
(fig. 36).

In Europe, owing to the predominance of the genus *Vespa*, black and yellow bands constitute a very dominant type of coloration among the Hymenoptera; but in Mashonaland (where *Vespa* is entirely absent) this pattern is of comparatively rare occurrence, and, except in the case of one large *Scolia* and some *Bembex*, is confined to small insects. The two Aculeates in the above group are common frequenters of flowers, and to them might have been added several small species of *Elis*, etc.; the Ichneumon is common in woods.

I. *Group with Dark Wings and Black-and-Yellow Legs: Ichneumonid Models* (Represented on Plate XXIII).

HYMENOPTERA.
Ichneumonidæ.
Osprynchotus flavipes
(fig. 32).

COLEOPTERA.
Longicornia.
Litopus dispar
(fig. 30).

HEMIPTERA.
Reduviidæ.
Pirates aeneicollis
(fig. 33).

The *Litopus* is evidently one of the protected Cerambycids, as shown by its diurnal habits, blue elytra, brightly-banded legs, and strong smell. The *Pirates*, with its dark wings and black-and-yellow legs, shows a distinct approximation to the former insect, which is probably of a Müllerian nature, as it is capable of emitting a strong and unpleasant smell, can pierce very effectively with its strong rostrum, and has the power of stridulation. *Osprynchotus* is also a conspicuous and very common insect. In South Africa it seems to be principally parasitic upon *Pelopeus spirifex*, and it is a curious thing that although these two insects are so very different in coloration (except the hind-legs), yet there is an undoubted similarity between them when seen together on the wing.

J. *Black and Yellow-Barred Braconid Group and Mimics* (Represented on Plate XVIII).

HYMENOPTERA	{ <i>Braconidæ</i>	Phanomeris dubius (fig. 59).
	{ <i>Ichneumonidæ</i>	Pimpla tuberosa (figs. 60, 61).
HEMIPTERA	<i>Reduviidæ</i>	Callilestes stigmatellus (fig. 62).

This is a beautiful little group, presenting very striking resemblances. The *Phanomeris* is doubtless the chief model, being a common species with a strong smell and a slow, conspicuous flight. The colouring of the *Pimpla* is probably Müllerian, while that of the Reduviid is certainly Batesian. The latter is evidently a very scarce insect, the only example which I have met with having been captured accidentally in mistake for the Braconid, to which it bears a wonderful resemblance on the wing.

K. *Black and Red Braconid Group and Mimics* (Represented on Plate XVIII).

HYMENOPTERA	<i>Braconidæ</i>	{ <i>Bracon coccineum</i> (figs. 53, 54); <i>Iphiaulax pictus</i> (fig. 55); <i>I. flagrator</i> (fig. 56).
COLEOPTERA	<i>Longicornia</i>	<i>Oberea scutellaris</i> (fig. 57).
HEMIPTERA	<i>Reduviidæ</i>	<i>Callilestes bicolor</i> (fig. 58).

In this group the pattern is certainly set by the *Braconidæ*, which are common, conspicuous, slow-flying insects, protected by their strong smell. The Reduviid is an admirable mimic of them (Batesian, as I believe) both at rest and on the wing; it is a scarce species, and frequents the same stations as the Braconids. The Longicorn agrees also in the latter respect, but its exact relationship to the group is doubtful; normally it is not a very common species in Salisbury, but in one or two seasons it has appeared quite plentifully, settling on low plants on wooded kopjes.

L. *Diptera Mimicking Single Species of Hymenoptera rather than the General Type of a Group.*

a. *Asilid Fly Mimicking Xylocopid Bee* (Represented on Plate XXII).

HYMENOPTERA.	DIPTERA.
<i>Xylocopa flavorufa</i> (fig. 19).	<i>Hyperechia marshalli</i> (fig. 20).

[With reference to these insects Mr. Marshall wrote:]

Salisbury, Feb. 12, 1899.—I was immensely delighted on catching the large Asilid fly, and I have been delaying the

box on purpose to include the large *Xylocopa* bee which it mimics so admirably; but though usually they are common enough I have not seen a single example for the last three weeks. The fly completely deceived me when on the wing, but I happened to notice it settle on the trunk of a tree, and it struck me there was something curious about the way it alighted for a *Xylocopa*. It is the only example I have seen.

Salisbury, April, 25, 1899.—I have already got a couple of the *Xylocopas* for you, and I have seen another specimen of the *Laphria* that mimics them, but unfortunately failed to catch it.

β. *Syrphid Fly Mimicking a Wasp* (Represented on Plate XXIII).

HYMENOPTERA.

Polistes marginalis (fig. 40).

DIPTERA.

Ceria gambiana (fig. 41).

This is an excellent and typical case of Batesian mimicry. The wasp is a very common species, building a small hanging nest on bushes or grass-stems. Like most of its congeners it is a somewhat sluggish insect, and instead of flying away when approached, adopts a bold and defiant attitude, stinging sharply when disturbed. It visits flowers freely, and may there be seen in company with the *Ceria*, which resembles it so closely (especially on the wing) that I have been deceived by it over and over again.

γ. *Bee-like Group* (Represented on Plate XXIII).

HYMENOPTERA.

Apidae.

Megachile apiformis
(fig. 37).

DIPTERA.

Syrphidae.

Eumerus, sp. nov.?
(fig. 38).

Asilidae.

Laxenecera mollis
(fig. 39).

The resemblance of the two flies to the *Megachile* is very marked in the field, especially in the case of the *Laxenecera*; although the plate does not do justice to the *Eumerus*. I have on several occasions seen all three species flying together in the vicinity of flowers.

M. *Group of Ant-like Insects captured together* (Represented $1\frac{1}{2}$ times the natural size on Plate XIX).

HYMENOPTERA	<i>Formicidæ</i>	{ <i>Camponotus sericeus</i> (fig. 54); <i>C. cosmius</i> (figs. 55, 56); <i>C. sp.</i> (fig. 53).
HEMIPTERA	<i>Pyrhocoridæ</i>	<i>Megapetus atratus</i> (figs. 57, 58).
ORTHOPTERA	<i>Locustidæ</i>	<i>Myrmecophana fallax</i> (fig. 59).

The above insects were all caught on the same day (Feb. 17, 1901) on a single plant—a small bushy vetch. The Pyrrhocorid habitually frequents this plant, being fond of sucking the young pods; the ants are more or less ubiquitous, but are principally attracted to this vetch by the juice which exudes from the injuries made by the bug; the *Myrmecophana*, which is apparently a very rare insect, was probably only a chance visitor. The latter, in spite of its long antennæ, bears a very strong resemblance to an ant, and might very readily be passed over for one of these insects; it is probably a Batesian mimic. The bug is not nearly so ant-like in its mature form (which is shown in Plate XIX) as in its earlier stages, at which period the similarity is most striking both in shape and movements. The insect is a comparatively common one, and the mimicry has probably a Müllerian character.

[The following extracts from letters refer to this interesting group. Mr. Malcolm Burr, to whom I have shown the Locustid, thinks that it may be the same species as *M. fallax*, inasmuch as the habits of the latter are not certainly known, and the green marking which obliterates the unant-like parts of the body-form had faded to a pale yellowish tint much like that of the corresponding parts of the specimen described by Brunner von Wattenwyl (verhandl. d. K. K. Zool.-botan. Ges. in Wien, Bd. xxxiii, 1883, Pl. XV, figs. 1a and 1b).—E. B. P.]

Salisbury, April 25, 1899.—The Locustid ant-mimicker *Myrmecophana* occurs both here (Mashonaland) and in Natal, though very rarely, but it is perhaps a different species from *M. fallax*. It does not live on the ground but on low plants, which are also frequented by the ant it mimics, and the light parts are pale green; we have also a bug which mimics the same ant.

Salisbury, April 19, 1901.—I expect you will be glad to have an example of *Myrmecophana*,—it makes a grand series with the ants and bugs; the two latter can often be

found together on a certain vetch, but it was a bit of luck getting the Locustid there too.

33. MIMETIC RESEMBLANCE OF MANTISPIDÆ TO HYMENOPTERA. (E. B. P.)

Prof. W. M. Wheeler, of the University of Texas, was, so far as I am aware, the first to observe the mimicry of Hymenoptera by *Mantispidæ*. "While studying the prairie insect fauna of south-eastern Nebraska early in the summer of 1888," he observed that *Mantispa brunnea* (Say.) closely resembled *Polistes variatus* (Cress), resting half-concealed like the wasp "on the petioles in the terminal leaf-clusters of the golden rods." He was at first quite deceived, and took care to avoid being stung. "The colouring of the *Polistes* is carefully copied; the body is banded with yellow, brown, and black, the wings are smoky brown, and the legs yellow. While lying in wait the *Mantispa* closely appose their large raptorial fore-legs to the lateral faces of the prothorax, which, when these appendages are extended, is so narrow as to resemble but slightly the wasp's thorax. The wings are carried in the same manner by both insects. Several times during the course of a week I found these two insects . . . resting in the same position, both intent upon the slaughter of the many insects . . . which swarmed about the rank vegetation" (Proc. Nat. Hist. Soc. Wisconsin, U.S.A., April 1889, p. 217). Professor Wheeler considers it to be an example of protective mimicry.

Mr. R. Shelford has recently observed that at least four species of *Mantispa* from Borneo and Singapore are beautifully mimetic of Ichneumonids, Bracons, or Aculeates. His observations are now being published by the Zoological Society. I sent a photograph of some of his examples to Mr. Marshall, who replied with the observation printed below. These interesting records constitute, so far as I am aware, a distinct addition to the list of insect mimics of the Hymenoptera. Mr. McLachlan, whom I have consulted, writes that he cannot find anything further recorded about such resemblance on the part of *Mantispidæ*. There can be little doubt, after these observations from three such widely-different regions, that mimicry of the Hymenoptera will prove to be prevalent in the group. Mr. Shelford and

Mr. Marshall both call attention to the cause which has doubtless prevented the fact from being generally recognized at an earlier date, viz. the changes which take place in dried specimens of *Mantispa*. On this account, and because of the important part played by movement, the appreciation of the mimetic resemblance required the study of the living insect.

"Salisbury, Sept. 21, 1900.—The large South African *Mantispa grandis* is an excellent mimic, on the wing, of the *Belenogaster* wasps. I caught one at Malvern, on my way home in 1896, which I gave to McLachlan. This insect completely took me in; it flew out of a loquat-tree which I was beating, and I at once took to my heels thinking I had struck a nest of these vicious wasps. Fortunately I kept an eye on the insect, and, as it seemed to be a species of *Belenogaster* new to me, I followed it up and caught it, when to my surprise and delight it proved to be only a *Mantispa*. Unfortunately in a dried specimen the resemblance is much spoilt by the shrivelling and discoloration of the abdomen."

34. CONVERGENT GROUPS OF SOUTH AFRICAN HEMIPTERA (G. A. K. M.)

A. Black and Red Lygæoid Group (Represented on Plate XIX).

<i>Lygæidæ</i>	{ <i>Lygæus rivularis</i> (fig. 44); <i>L. elegans</i> (fig. 46); <i>L. crudelis</i> (fig. 47); <i>Graphostethus servus</i> (fig. 45).
<i>Reduviidæ</i>	
	<i>Reduvius</i> sp. (fig. 43).

In this group I consider that the Lygæids form a Müllerian association, of which the *Reduvius* is probably a Batesian mimic. The former insects are very abundant, occurring on many different plants, but the *Lygæi* are especially fond of the balloon-like seed-vessels of *Gomphocarpus*. The *Reduvius* inhabits much the same stations, though I have never seen it (to my remembrance) actually in company with the Lygæids, and it is a decidedly rarer insect.

B. Group of Yellow Hemiptera with Black Apex and one or two Black Bars (Represented on Plate XIX).

At Malvern, Natal.

<i>Pyrrhocoridae.</i>	<i>Reduviidae.</i>
<i>Dysdercus nigrofasciatus</i> (fig. 49).	<i>Phonoctonus nigrofasciatus</i> (fig. 48).

At Salisbury, Mashonaland.

<i>Pyrrhocoridae.</i>	<i>Reduviidae.</i>
<i>Dysdercus superstitiosus</i> (fig. 50).	<i>Phonoctonus formosus</i> (fig. 52).
„ <i>intermedius</i> (fig. 51).	

The significance of the mimicry in this group has not yet been tested by experiment, and the exact relationship of the Reduviids to the common and undoubtedly distasteful *Dysderci* is not quite clear. Dr. Dimock Brown, who observed *Phonoctonus* in company with myself at Malvern, suggested that its colouring may be pseudemisematic, and that it may feed upon the *Dysdercus* which it mimics so marvellously well. Personally I incline rather to the belief that both this species and the northern *P. formosus* are Batesian mimics. Both species occur but rarely (indeed, of the latter, I know only two specimens), they do not possess the strong smell which characterizes some of the Reduviids, and their jointed rostrum is a very inefficient weapon for protective purposes. I am not aware that they have been observed feeding on *Dysderci* or even in company with them (cf. G. Breddin, Zeitsch. f. Naturw. 1896, pp. 36-38).

[Breddin considers the resemblance of the Reduviid to be a case of aggressive (pseudemisematic) mimicry, as he thinks with Dr. Dimock Brown it would prey on the *Dysdercus*. I believe that all such groups in the Hemiptera are synaposematic.—E. B. P.]

35. MISCELLANEOUS OBSERVATIONS ON SOUTH AFRICAN INSECTS. (G. A. K. M.)

A. Note on the Courtship of *Limnas chrysippus*.

Salisbury, June 26, 1900.—In some old notes I find the following observation on the courtship of *chrysippus*. When first observed the female was settled on the

ground and was sharply fluttering her wings to keep off the male which was hovering above her. Whenever she rested for a moment with open wings the male would drop down on her, trying to settle on the costa of her fore-wing in such a position that the badge on his hind-wing came directly down on her head; and while hovering over her, his position was usually at right angles to hers, which renders it probable that the badge is some sort of scent-gland used for attractive purposes. The female however kept on fluttering pretty incessantly, and the male kept bumping down on her. Then another male came round and the first one went off and had a skirmish with him and drove him away. The female then took flight, the male usually keeping above her and trying to beat her down to the ground again. The female, on settling, renewed her defensive fluttering, and the male, apparently getting tired, flew off. The whole observation occupied five minutes. I never saw any use made by the male of his curious terminal tufts.

B. *The possible meaning of the Sac of Female
Acræinæ.*

Malvern, May 14, 1897.—The species in which the sac is best developed are *Acræa neobule* and *A. horta*. With regard to the use of the organ, I remember making some observations at Salisbury in 1894 on *A. caldarena* and *A. nohara-halali* while ovipositing, and I then came to the conclusion that the sac was of no use during laying, being apparently rather an obstruction than otherwise. I therefore rather incline to your second suggestion, that it is probably to prevent copulation a second time. This view moreover seems to be borne out by what I have noticed in the courtship of the insects. So far as I have at present observed, Acræas appear to be the only butterflies which indulge in the system of "marriage by capture." In such of the *Nymphalinae* as I have watched, the males have in no case attempted to seize the females, which, when anxious to escape their addresses, did so either by dodging among the vegetation or soaring. The females of some *Pierinae* (notably *Belenois*, *Pinacopteryx*) have a very noticeable method of refusing the males; they settle with wings outspread but with fore-wings directed backwards so as almost to cover the hind-wings, and the abdomen is

raised in the air. This position is probably to prevent the male running along the side, for copulation is effected from the side. It might however be done in order to allow the male to see by her abdomen that she was gravid, for I have a case in my note-book (*P. pigea*) in which the male ran up and felt the abdomen with his palpi and then flew off. In the *Acræas* however I have observed several cases of copulation taking place in *A. petraea* and *A. hortæ*, and in all of them the male seized the female on the wing, grasping her with his intermediate legs about the thorax or base of the fore-wings, and they would fall struggling to the ground, where coition would take place. If this is the normal method of copulation, and unfortunately my observations have been too few to enable me to feel sure of it, then any organ which would protect the female from the attentions of an unlimited number of males would not only be useful but absolutely necessary.

Malvern, July 15, 1897.—The other day I saw a pair of *Acræa encedon* struggling together on the ground, the male clasping the female round the thorax from below. Unluckily a second or two after I noticed them they separated, so that I had not time to see whether it was really the sac which prevented coition. However I caught the female and found she had the sac fully developed and hard.

C. A Rhodesian Muscid Fly Parasitic on Man.

[Mr. E. E. Austen informs me that the fly sent by Mr. Marshall belongs to the *Muscidæ*, and is certainly a near ally of the genus *Bengalia*. A closely similar or possibly identical species with precisely similar habits occurs on the West Coast of Africa. Mr. Austen's observations upon this latter entirely confirm Mr. Marshall's conclusions as to the method by which the larva enters the skin. Mr. Austen proposes to publish a full description of the species—E. B. P.]

Salisbury, April 19, 1901.—I should be glad to know the name of the parasitic fly I send. It has been a great scourge this year in Salisbury, especially among young babies, the maggots forming a painful boil-like swelling under the skin. One baby had no less than sixty maggots extracted from it, and there have been several cases in which they have had a dozen or more.

Salisbury, Sept. 27, 1901.—The fly which lays eggs in man is very common here, but I have no specimens by me; I will catch you a series as soon as they appear again. The one I sent you was a male, the female is very much larger. I am much puzzled to understand how the larva obtains an entrance into the skin. It certainly cannot be through the stomach as in the case of some other bots. I fancy the egg or living larva must be laid on the clothing, and the latter being very minute might wander about and eventually enter the skin through a pore without being felt. The position of the bots in many cases renders it impossible for the egg to have been placed under the skin by the mother.

APPENDIX.

Description of a new species of Hyperechia, Schin.
(Family ASILIDÆ), from Mashonaland. By ERNEST
E. AUSTEN.

HYPERECHIA, Schiner :

Verhandlungen der kaiserlich-königlichen zoologisch-botanischen Gesellschaft in Wien, xvi. Band, p. 673 (1866).

Hyperechia marshalli, sp. nov. (Pl. XXII, f. 20.)

♂. Length 28 millim.

Black, abdomen steel; cheeks, posterior margin of thorax in front of scutellum, outer side of front tibia, under side of thorax between bases of legs and in front of front coxæ, and outer side of middle femora, except apical fourth, clothed with orange-rufous* hair: fringe on posterior margin of thorax very conspicuous, and more ferruginous† than orange-rufous.

Front and face clothed with ochraceous hair; mystax ochraceous above and black below, with two or three black hairs in the middle

* Ridgway, "A Nomenclature of Colors" (Boston: Little, Brown and Coy., 1886), Pl. IV, 13.

† Ridgway, *op. cit.*, Pl. IV, 10.

line above. Tips of *front femora* on outside clothed with orange-rufous hair; a large tuft of similar hair on the pleuræ below the humeral angles. *Thorax* duller than abdomen, and, except on posterior margin and also in front, where there is some ochraceous pile, clothed with very short black hair. *Legs* thickly fringed with black hair, except where otherwise stated. *Wings* of the usual blackish-brown tint, with a slightly purplish sheen, which, however, is not so conspicuous as in the case of *H. xylocopiformis*, Walker.

Salisbury, Mashonaland; Feb. 1899 (G. A. K. Marshall): one specimen. Type in the Hope Museum, Oxford.

I have much pleasure in associating this fine new species with the name of its discoverer.

It may be of interest to note that the genus *Hyperochia* occurs in the Oriental as well as in the Ethiopian Region: *Hyperochia* (*Laphria*) *xylocopiformis*, Walk., the type of the genus, was described from a specimen from Madras, while *H. fera*, v. d. Wulp, occurs in Borneo.

Descriptions of new species of South African Rhynchota.

By W. L. DISTANT.

Family PYRRHOCORIDÆ.

Megapetus, gen. nov.

Head elongately subquadrate, narrowed in front of insertion of antennæ, apex truncately rounded, outer margins of eyes not so wide as posterior angles of pronotum, antennæ four-jointed, simple, second and third joints subequal in length, each shorter than first, fourth much the longest; pronotum with the lateral margins convex, narrowed anteriorly to base of head, lateral angles spinously produced, posterior margin truncate; hemelytra rudimentary; scutellum triangular; abdomen inflated; rostrum reaching the intermediate coxæ, basal joint very robust, subequal to or very slightly shorter than second joint; legs simple, posterior legs much the longest, posterior femora obsoletely spinous before apex.

Allied to *Myrmoplasta*, Gerst.

Megapetus atratus, sp. nov. (Pl. XIX, f. 57-58 × 1½.)

Black; antennæ pale fuscous, basal half of first joint greyish, fourth joint dark fuscous; head anteriorly somewhat longly greyish pilose; in ♂, base of abdomen black with a small whitish spot near each anterior lateral angle, in ♀ base of abdomen brownish;

posterior pronotal angles distinctly spinously produced, the spines directed a little backwardly; the upper surface is very finely and somewhat sparingly pilose; base of anterior tarsi pale fuscous; in ♀ the intermediate tibiæ somewhat brownish.

Long. 8 millim.; exp. pronot. angl. $2\frac{1}{2}$ millim.

Hab. MASHONALAND; Salisbury (*G. A. K. Marshall*).

Type in the Hope Museum, Oxford, and in Coll. Distant.

Dysdercus intermedius, sp. nov. (Pl. XIX, f. 51.)

Above pale ochraceous; head, anterior area and lateral margins of pronotum, basal area of lateral pronotal margins, scutellum, body beneath rostrum, and legs reddish-ochraceous or pale sanguineous; antennæ, discal narrow transverse fascia to corium, membrane, tibiæ, tarsi, and anterior margins of sternal and abdominal segments, black; anterior margin of pronotum broadly, posterior margin narrowly, anterior and posterior margins of prosternum, lateral and posterior margins of pro- and mesosterna, lateral and posterior margins of abdominal segments and the coxæ, pale luteous; anterior femora spined beneath at apex; second joint of antennæ slightly shorter than the first the base of which is reddish.

Long. 16 to 21 millim.

Hab. GERMAN EAST AFRICA (*Capt. Atkinson*—Brit. Mus.). MASHONALAND; Salisbury (*G. A. K. Marshall*).

Type, from German East Africa, in the British Museum.

Specimens from Mashonaland in the Hope Museum, Oxford, and in Coll. Distant.

Intermediate between *D. superstitiosus*, Fabr., and *D. cardinalis*, Gerst. From the first it differs by the absence of the black fascia to the posterior margin of the pronotum and the transverse fascia to the corium; from *D. cardinalis* it differs by the black tibiæ and tarsi.

Family REDUVIIDÆ.

Phonoctonus formosus, sp. nov. (Pl. XIX, f. 52.)

Pale luteous; head, anterior lobe of pronotum, rostrum, anterior and intermediate femora, base of posterior femora, and coxæ sanguineous; antennæ, scutellum (excluding apex), an indistinct transverse fascia to corium at and somewhat confused with base of membrane, tibiæ and tarsi, posterior femora, central area of intermediate femora, membrane, and apex of rostrum black; sternum

piceous, lateral and posterior segmental margins, luteous; abdomen beneath luteous, lateral and posterior segmental margins, sanguineous, apex fuscous.

Anterior lobe of pronotum posteriorly sulcate, posterior lobe entire, the last with its anterior lateral margins narrowly black; body beneath, sparingly and finely pilose.

Long. 19 millim.

Hab. ANGOLA (Brit. Mus.). MASHONALAND; Salisbury (*G. A. K. Marshall*).

Type, from Angola, in the British Museum.

Specimens from Mashonaland in the Hope Museum, Oxford.

Callilestes stigmatellus, sp. nov. (Pl. XVIII, f. 62.)

Ochraceous; anterior lobe of pronotum, lateral margins of pro- and mesosterna, the metasternum, and abdomen beneath reddish-ochraceous; antennæ, apex of head, eyes, and a transverse fascia between eyes, a postmedian transverse fascia and the apical angles to corium, membrane, tarsi, and posterior tibiæ black; bases of posterior tibiæ, basal angle and a central spot to membrane, ochraceous.

Anterior and posterior pronotal lobes with a distinct central sulcation, scutellum with a strong, circular, basal foveate impression; posterior lobe of pronotum, scutellum and corium thickly and finely punctate; femora moderately nodulose and with the tibiæ distinctly pilose; hemelytra extending considerably beyond the apex of the abdomen.

Long. incl. membr. 14 millim.

Hab. MASHONALAND; Salisbury (*G. A. K. Marshall*).

Type in the Hope Museum, Oxford.

Descriptions of new species of South African Hymenoptera.

By COLONEL C. T. BINGHAM.

Chalcis bicolor, sp. nov. (Pl. XXIII, f. 10.)

♂. Head, thorax, the coxæ and trochanters of the anterior, and intermediate, and the upper side of the coxæ, the trochanters, tibiæ and tarsi of the posterior legs black, the femora and tibiæ of the anterior and intermediate legs, the front of the posterior coxæ, the posterior femora and the abdomen orange-yellow, the apex of the mandibles castaneous, the tibial calcaria of the hind-legs yellow.

Head and thorax coarsely closely punctured, cribrate, the wide deep antennal groove on the face, and the mesopleuræ transversely striate, the scutellum broad and convex above, posteriorly bidentate, the postscutellum and median segment shining, the latter areolated and bearing a strong tooth on each side; legs finely punctured opaque, abdomen smooth and shining. The sides of the broad vertical furrow on the front of the head, the cheeks and the metapleuræ covered densely with long white hairs, the legs and the rest of the head and thorax with sparse shining white pubescence. Wings dark fuscous with a purple iridescence in certain lights.

Length ♂ 9 m.m.; *exp.* 17 m.m.

Hab. Salisbury, 5000 feet, MASHONALAND, SOUTH AFRICA.

Bears a superficial resemblance to *C. semirufa*, Walker, from the Oriental Region, but in sculpture and in the distribution of colour widely different.

Type in the Hope Museum, Oxford.

Iphiaulax ruber, sp. nov. (Pl. XXIII, f. 31.)

♀. Red, the front below the antennæ, the head above, the cheeks, except a narrow line behind the eyes, the antennæ, the apex of the mandibles and the claws black; wings fusco-violaceous, the basal three-fourths of the stigma and two obscure spots beneath it on the fore-wing reddish hyaline. Head smooth and shining, a semicircular transverse depression in front of the ocelli. Thorax glabrous, shining; mesonotum gibbous, the parapsidal grooves indistinct; the scutellum triangular somewhat laterally compressed, the postscutellum transverse; the median segment elongate obliquely sloping to the apex not areolated, the pear-shaped stigmata placed in a depression on each side. Head, thorax and legs covered with a fine, short, erect, brownish pubescence. Abdomen somewhat elliptical, as long as the head and thorax united; basal segment with a raised longitudinal rectangular centre portion smooth and shining, the lateral margins foveate and bounded by a carina, the apex of the raised part depressed, longitudinally striate and margined by a transverse broad carina; 2nd segment with a medial subtriangular plate smooth and shining from which coarse divergent striæ radiate in the deep depressions on each side, these depressions bounded laterally and posteriorly by raised carinæ; remaining segments coarsely punctured, rugose, the sutures between the segments 2-5, and oblique lateral grooves on segments 3-5 crenulate.

Length ♀ to apex of abdomen 20; of ovipositor 22 m.m.; *exp.* 38 m.m.

Hab. Salisbury, 5000 feet, MASHONALAND (*G. A. K. Marshall*).

Type in the Hope Museum, Oxford.

Phanomeris dubius, sp. nov. (Pl. XVIII, f. 59.)

♀. Reddish-yellow, the apex of the mandibles, the eyes, the antennæ, a triangular spot enclosing the ocelli, and the ovipositor black, the posterior tibiæ shaded with fuscous black; wings hyaline yellow shaded as follows, fore-wing the stigma jet black, a spot at the apex of the median cell, spreading across the nervure into the 1st discoidal cell, a spot at the base of the 2nd discoidal cell, a bar interrupted below crossing the disc of the wing below the stigma, and the apical margin of the wing fuscous; hind-wing, a spot beyond the transverse nervure closing the median cell, and the apical margin of the wing broadly, fuscous. Head cubical, the front above the antennæ, the vertex, occiput and cheeks smooth and shining, head in front below the antennæ closely and somewhat coarsely punctured rugose. Thorax not broader than the head coarsely but sparingly punctured, the mesonotum gibbous, the parapsidal grooves deep, the scutellum compressed smooth, legs moderately long with the femora and tibiæ incrassate; median segment finely and closely punctured rounded above, and bearing a delicate median longitudinal carina. Abdomen longer than the head and thorax united, elongate oval, the basal two segments finely striate above, the disc of the 2nd segment raised, the raised portion semicircular, the depression on either side of the raised portion above smooth, the suturiform articulation distinct, crenate, the apical segments smooth and shining with transverse impressions at their bases, these latter crenulate. Ovipositor longer than the head and body, the sheath densely pubescent.

Length ♀, to apex of abdomen 17 m.m.; ovipositor 26 m.m.; *exp.* 32 m.m.

Hab. Salisbury, 5000 feet, MASHONALAND, SOUTH AFRICA (*G. A. K. Marshall*).

It is with much doubt that I record this species under Forster's genus *Phanomeris*. It has the appearance of a *Vipio*, but there are no tufts of hair at the base of the clypeus, the submedian cell in the fore-wing is longer than the median cell, and in the hind-wing the submedian cell is about equal to half the length of the median cell.

Type in the Hope Museum, Oxford.

Pompilus marshalli, sp. nov. (Pl. XXIII, f. 20.)

♀. Resembles *P. collaris*, Saussure, from Madagascar, but the thorax is comparatively longer, the scutellum not so raised and prominent, and the median segment is almost cylindrical very convex above, roughly transversely striate, and posteriorly truncate but not concave. In *P. collaris* the median segment is smooth almost flat above, while the posterior face is concave with the sides distinctly produced backwards.

Black with a beautiful purplish bloom on the abdomen above; the head with the mandibles and the scape of the antennæ, the pronotum, the tibiæ and tarsi of the anterior, and the tibiæ and base of the first joint of the tarsi of the intermediate and posterior legs red; wings fusco-violaceous the posterior scarcely lighter in colour than the anterior wings. In *P. collaris* the fore-wing is markedly darker than the hind-wing. Abdomen massive as long as the head and thorax united. Base of the 2nd ventral segment with a distinct transverse groove; pygidial area densely pubescent.

Length ♀ 20; exp. 28 m.m.

Hab. Salisbury, 5000 feet, MASHONALAND (*G. A. K. Marshall*).

This species belongs to Kohl's *ferreola* group of *Pompilus*.

Type in the Hope Museum, Oxford.

Description of a new species of Carabidæ from South Africa. By GUY A. K. MARSHALL.

Polyhirma bennettii, Mshl., sp. nov.

Long. 15 m.m. Length of elytra 8 m.m.; width at base 1.75 before middle 3, at apex 1.75 m.m.

Body depressed and very elongate. Colour black with a broad line of thin greyish pubescence from labrum to basal part of elytra; the foveæ of the elytra filled with ferruginous pubescence, and at the apex an elongate sutural white patch.

Head broadly depressed in middle, indistinctly punctured and with a short central carina just behind the labrum, which is bare and impunctate; eyes prominent; the band of pubescence very broad in front, narrow posteriorly. *Antennæ* strongly compressed, black; the three basal joints shiny and with sparse white pubescence

exteriorly ; the remaining points appear dull owing to their being strongly aciculate, except for a narrow smooth central line. *Prothorax* elongate, broadest at apex, sides subparallel nearly to middle and thence strongly narrowed to base. A broad central furrow throughout, containing the pubescent stripe, and a deep short stria on either side of it at base ; punctuation strong, close and even. In the basal portion the lateral part of the thorax is produced so as to extend a good deal beyond the dorsal edge from which it is separated by a very deep incision. The mesonotum is broadly exposed and bears a part of the central pubescent stripe. *Elytra* very narrow and elongate, scarcely broader than the head at their widest part, which is before middle. Sides distinctly rounded, apex broadly truncate. Dorsal surface very much flattened, with six sharp, narrow carinæ (the sutural one not reaching the base) and a very short apical one between the 5th and 6th ; all the carinæ disappear before reaching the apex ; the 6th carinæ form the dorsal edges of the elytra, the portions between them and the true edges being folded over underneath so as to form false epipleura. The spaces between the carinæ are occupied by large reticulate foveæ, filled with ferruginous pubescence, which are largest near the suture and diminish in size laterally. The basal sutural stripe is short, being about as long as the apical white patch ; the latter is narrow and elongate, bifid posteriorly and reaches the extreme apex. *Legs* black with fine white pubescence ; the posterior pairs of femora are more strongly compressed than in any other species of the genus.

This remarkable species was discovered at Somerset West, Cape Colony, in January 1900, by Mr. E. N. Bennett, M.A., Fellow of Hertford College, Oxford, to whom I have dedicated it. Its depressed and narrow form is more suggestive of a subcortical insect than of a terrestrial *Polyhirma*, and the folding under of the elytral margins is a unique character in the genus. The species to which it is most nearly allied is *P. macilentæ*, Ol., from which it may at once be distinguished by its very different facies ; and it also differs in the following points : (1) the costæ of the elytra are extended further towards the apex (as in *P. semisuturata*, Chd.) ; (2) the costæ are sharper and straight, not undulating ; (3) the prothorax is not nearly so heart-shaped, owing to the sides not being rounded in front. The last two points, as well as the shortness of the basal stripe on the elytra, distinguish it from *semisuturata*.

The type is in the Hope Museum, Oxford,

*Description of a new species of TELEPHORIDÆ from
Mashonaland.* By J. BOURGEOIS.

Lycocerus mimicus, sp. nov. (Pl. XVIII, f. 11 ♂, f. 12 ♀.)

Oblongus, subparallelus, niger, pubescens; capite prothoraceque dense punctulatis, nitidiusculis, hoc antice leviter reflexo-marginato, ad latera incrassato et vage rufo-limbato; elytris opacis, tomentosis, ruguloso-punctatis, flavo-testaceis, apice nigris, costis duabus obsoletis singulatim notatis; corpore subtus nitidiusculo, nigro, abdomine lateraliter flavo-marginato; unguiculis simplicibus, rufis.

♂. Prothorace subelongato, antice rotundato, lateribus parallelis, subrectis, haud marginatis, disco longitudinaliter sulcato; abdominis segmento ultimo bialvato, valva inferiori cupuliformi.

♀. Prothorace transverso, antice arcuato, lateribus minus parallelis, anguste submarginatis, sulco dorsali obsoleto; abdominis segmento ultimo integro, semilunato.

Long. 9-11 mill.

Hab. MASHONALAND; Salisbury (*G. A. K. Marshall*).
Sex (♂, ♀).

Type in Hope Museum, Oxford.

C'est la première espèce africaine connue du genre *Lycocerus*, Gorham (Proc. Zool. Soc. Lond., 1889, p. 108). De même que ses congénères asiatiques, dont elle diffère surtout par la coloration, elle présente une certaine analogie de facies avec les Lycides du groupe des Calochromides. Chez le ♂, le prothorax est plus étroit et plus allongé que chez la ♀. En outre, dans l'exemplaire que j'ai sous les yeux, le pronotum présente, de chaque côté du milieu et contre le liseré roussâtre qui existe dans les deux sexes, une autre petite tache rousse qui manque dans la ♀. Mais je ne saurais dire si cette particularité de coloration est constante.

EXPLANATION OF PLATE IX.

INJURIES TO WINGS OF SOUTH AFRICAN BUTTERFLIES.

Injuries inflicted at the apex or hind margin of one or both fore-wings, or near the overlap of fore- and hind-wings, or at two or more points in the total wing margin.

All the figures are about $\frac{2}{3}$ of the natural size.

All the specimens were captured, on the dates mentioned, at Salisbury, Mashonaland, 5000 feet, by Guy A. K. Marshall.

- FIG. 1. *Limnas chrysippus* ♀, Sept. 22, 1900. Very rarely settles on the ground, so that the attacks of lizards are not likely to be common.
2. *Parosmodes icterica*, March 9, 1898. Found in the bush and woodland districts, settling on flowers. Probably injured when flying, as it rests with its wings closed.
3. *Junonia cebrenae* ♂, Feb. 15, 1899. Settles on the ground, injuries were very probably inflicted by a lizard.
4. *Acræa anemosa* ♂, March 11, 1899. Flies high for an *Acræa*, and never settles on ground: feeds on tree flowers, and usually at some height. The injury was probably caused by a bird.
5. *L. chrysippus* ♀, March 11, 1898.
6. *Catochrysops mashuna* ♂, Sept. 29, 1900. Flies very rapidly, settles on low flowers and the ground, rests at night on grass-stems. The injury was probably caused by a lizard.
7. *A. anemosa* ♀, Jan. 2, 1899.
8. *Teracolus omphale* ♂, March 31, 1901. Flies rapidly, settles on low flowers and ground, so that lizards are probable enemies, but the narrow symmetrical notch rather suggests a bird's beak.
9. *Atella phalantha* ♂, March 22, 1899. Flies rapidly, settling on bushes and flowers and not on the ground. Birds are the probable enemies.
10. *L. chrysippus* ♀, July 14, 1901.
11. *L. chrysippus* ♀, Jan. 2, 1898. The evidence of crumpling, the scratching of the surface, as well as the extensive injuries point to the probable attack of a mantis.
12. *A. phalantha* ♀, March 5, 1899. Tips of both fore-wings snipped off, probably by a bird.

- FIG. 13. *A. nohara*, form *halali*, March 9, 1898. Flies low and settles on low flowers and the ground. A lizard is a probable enemy except that the injury is unilateral and the insect closes its wings in all but the short rests, when it opens and shuts them.
14. *Catopsilia florella* ♀, Dec. 18, 1898. Flies very rapidly, rests on trees under leaves, visits flowers and bushes. It only settles on the ground to drink in damp places. It is unlikely to be attacked by a lizard, and the character of the injury probably indicates a bird.
 15. *Precis sesamus* ♀, April 8, 1901. Probably injured by a bird: the notch is too narrow for a lizard. The specimen was evidently freshly emerged.
 16. *Terias brigitta* ♀, December 18, 1898. Flies slowly and settles on the ground and low flowers. Probably attacked by lizard.
 17. *C. florella* ♂, Jan. 21, 1899. The injury *strongly* suggests the beak of a bird. Both wings are symmetrically snipped.
 18. *C. florella* ♂, Jan. 14, 1899. The habits imply that birds are the usual enemies.
 19. *P. sesamus* ♂, April 8, 1901. The shape of the tear is such as might have been made by a lizard, and the habits of the butterfly render it quite probable that the injury was thus caused. A very fresh specimen.
 20. *Pseudonympha extensa* ♂, Jan. 2, 1899. A woodland species with feeble flight, settling on low flowers and the ground. It was very probably attacked by a lizard.
 21. *Terias brigitta* ♂, March 9, 1898. Similar to description of Fig. 16.
 22. *Belenois severina* ♂, Jan. 25, 1899. Flight like that of *Teracolus omphale*, see Fig. 8 description. Attack of lizard probable.
 23. *Precis archesia* ♂, April 8, 1901. The character of the injury suggests the attack of a bird. Very fresh specimen.
 24. *Precis antilope*, form *simia* ♀, Dec. 31, 1898. All *Precis* in woodland and open country settle frequently on rocks and ground. The injury probably caused by a lizard.
 25. *B. severina* ♀, Feb. 1, 1899. Probably injured by a lizard.

EXPLANATION OF PLATE X.

INJURIES TO HIND-WINGS OF MASHONALAND AND HOLARCTIC BUTTERFLIES.

Injuries inflicted at the anal angle or hind margin of one or both hind-wings, suggesting that the insect was being pursued or, if settled, approached from behind.

All the figures are $\frac{2}{3}$ of the natural size.

All the specimens not otherwise described were captured on the dates mentioned by Guy A. K. Marshall at Salisbury, Mashonaland, 5000 feet.

- FIG. 1. *Limnas chrysippus* ♀, July 14, 1901.
 2. *Atella phalantha* ♀, Jan. 18, 1899.
 3. *Hypolimnas misippus* ♀, April 10, 1898. Flies like its model *chrysippus* until disturbed, when it is swift. Settles on low flowers. Lizards probable enemies. Very fresh specimen.
 4. *A. phalantha* ♂, March 26, 1899. Character of injury strongly suggests a bird's beak.
 5. *A. phalantha* ♀, Dec. 1900.
 6. *Byblia acheloia* ♂, Feb. 25, 1899. The species of *Byblia* fly low at a medium pace, and settle on low plants and occasionally on the ground, they rest at night on grass-stems. Lizards are probable enemies, but the character of the injury rather suggests a bird.
 7. *Acraea rahira* ♀, Dec. 31, 1898. Marsh insects, settling on flowers in low marshy places where lizards are not often seen, hence birds are more probable enemies. Mr. Marshall noted concerning the specimen here represented, when it was in the fresh state, "judging from the state of the abdomen this insect had been caught and rejected, presumably by a bird."
 8. *Nyctemera leuconoë*, April 8, 1901. Never settles on ground. It almost invariably covers its hind-wings directly it settles, assuming a **A** shape, although it occasionally walks a short distance with its wings erect. The injury was almost certainly inflicted during flight by a bird.
 9. *Pyrameis cardui*, var. ♀, Jan. 1900. Often settles on ground. Lizards probable enemies.
 10. *Byblia ilithyia* ♂, Jan. 27, 1899.
 11. *B. ilithyia* ♂, Feb. 1, 1899.

FIG. 12. *B. acheloïa* ♂, Feb. 22, 1899.

13. *Cyclopides willemi* ♂, March 1, 1899. A woodland insect settling on flowers and never on ground. Rests at night on grass-stems. Probably attacked on the wing, as the injury is unilateral and the butterfly closes its wings when settled.
14. *Pseudonympha vigilans* ♂, March 17, 1901. A rock butterfly, lizards the probable enemies.
15. *Junonia cebrene* ♂, Jan. 14, 1899.
16. " " Feb. 18, 1899.
17. *C. willemi* ♂, March 11, 1899. If this butterfly was attacked, a bird is the probable enemy.
18. *Herpænia eriphia* ♀, March 9, 1898. Flies slowly and rather low, settling on flowers and the ground like a *Teracolus*. Lizards the probable enemies.
19. *Mylothris rüppelii* ♂, Feb. 1900. Slow flapping flight, settling on flowers and twigs of bushes in exposed positions. The wings are generally open during a short rest. The hind-wing was probably shorn through by a bird.
20. *Terias senegalensis* ♂, Jan. 21, 1899.
21. *T. regularis* ♀, May 24, 1901.
22. *Belenois severina* ♀, Jan. 25, 1899.
23. " " ♂, Feb. 15, 1899.
24. *Catopsilia florella* ♂, Dec. 18, 1898.
25. *Teracolus achine* ♂, April 16, 1899.
26. *Argynnis cybele*, Aug. 2, 1897. Captured by E. B. Poulton, near North Lake, Hartland, Wis., U.S.A. A flower-haunting fritillary very probably injured by a bird.
27. *B. severina* ♂, Feb. 15, 1899.
28. *Epinephele janira* ♀, Aug. 15, 1900. Captured by A. H. Hamm, near Dawlish, S. Devon. Both hind-wings probably shorn through by a bird; lizards are not important enemies in this country. The straight line of the injury also suggests a bird's beak.
29. *Melanargia galathea*, July 21, 1898. Captured by E. B. Poulton on the Stalden Rd., near Visp, Valais, about 2300 feet. The injury might well be by a lizard, but in Europe they are not nearly such important enemies as they become further south.
30. *Lycæna icarus*, July 26, 1898. Captured by E. B. Poulton at Creux de Genthod, N.W. shore of the Lake of Geneva, 1230 feet. The character of the injury clearly suggests a bird.

- FIG. 31. *Vanessa atalanta* ♂, Aug. 23, 1897. Captured by F. A. Dixey at Morthoe, N. Devon. The injury can hardly have been produced otherwise than by a bird snipping a notch in all four wings when they come together in the attitude of repose as shown in the figure.
32. *Epinephele lycaon*, July 22, 1898. Captured by E. B. Poulton between Visp and Stalden, Valais, about 2450 feet. The same conclusion as in the description of Fig. 29.
33. *Vanessa atalanta* ♂, Sept. 23, 1901. Captured by A. H. Hamm in the University Parks, Oxford. The character of the injury implies an attack by a bird, probably made in one of the short rests when the insect assumed the attitude shown in the figure.

EXPLANATION OF PLATE XI.

INJURIES TO DIRECTIVE MARKS AND STRUCTURES ON THE WINGS OF SOUTH AFRICAN BUTTERFLIES.

Injuries inflicted in the neighbourhood of special marks or structures near the anal angle of hind-wing or apex of the fore-wing.

All the figures are about $\frac{2}{3}$ of the natural size.

All the specimens not otherwise described were captured, on the dates mentioned, at Salisbury, Mashonaland, 5000 feet, by Guy A. K. Marshall.

- FIG. 1. *Precis antilope* ♂, May 19, 1898. Rests on leaves of low herbage and rarely on the ground. Birds are the most likely enemies, and the specimen was probably at rest when both "tails" were shorn off.
2. *Precis cuama* ♀, May 1900. Same habit and conclusions as in the last figure.
3. *Spindasis natalensis*, June 13, 1900. Captured by Champion B. Russell near Eshowe, Zululand. Flight very rapid, settles on outer leaves of trees and never on ground. Almost certainly injured by a bird.
4. *Precis archesia* ♂, March 9, 1901. This unilateral injury was probably inflicted on the wing.
5. *Charaxes guderiana* ♂, Dec. 31, 1898. All *Charaxes* here represented fly and settle like *S. natalensis*. Birds by

far the most probable enemies unless there is evidence of the attacks of a mantis (possible but not likely in the example represented in this figure).

- FIG. 6. *Tarucus plinius* ♂, March 11, 1899. Flies at medium pace, settles on bushes and low trees, birds the probable enemies. The injury moreover suggests a bird.
7. *Hypolycaena philippus* ♂, March 11, 1899. Habits and conclusions as in the last figure. These two Lycænids and many other butterflies will settle on the ground in damp spots to drink, but Mr. Marshall has not seen lizards in such places.
 8. *Papilio demodocus* ♂, March 2, 1901. Flies rapidly, settling on flowering bushes; probable enemies mantides or birds; lizards improbable. Character of injury suggests posterior part of both hind-wings shorn off while at rest by a bird.
 9. *P. demodocus* ♂, Jan. 24, 1901. Same conclusion as in last figure.
 10. *Charaxes achæmenes* ♀, March 6, 1898. See description of Fig. 5.
 11. *Catochrysops parsimon* ♀, Jan. 25, 1899. Very rapid flight, settling on ground and low veldt flowers and at night resting on grass-stems. Lizards probable enemies, but the character of the injury suggests a bird.
 12. *Axiocerces harpax* ♂, March 3, 1899. Habits and conclusions as in Figs. 6 and 7.
 13. *Charaxes saturnus* ♂, March 6, 1898.
 14. " " " March 12, 1898.
 15. *C. guleriana* ♀, March 6, 1898. In this and the two preceding figures, see description of Fig. 5.
 16. *Uranothauma poggei* ♂, Jan. 1901. A woodland species flying at medium pace and settling on low flowers. Birds probable enemies.
 17. *T. plinius* ♀, March 11, 1899. Injury suggests bird. Probably seized on the wing.
 18. *Axiocerces amanga* ♂, Dec. 27, 1900. Habits and conclusions as in Figs. 6 and 7. Probably seized at rest with wings closed.
 19. *H. philippus* ♂, March 11, 1899. Injury suggests bird. Probably attacked at rest.
 20. *C. saturnus* ♂, Jan. 2, 1899. Symmetry of injury suggests conclusions as in Figs. 8 and 9.
 21. *Teracolus actine* ♂, April 9, 1899.
 22. " " " April 2, 1899.

FIG. 23. *Teracolus achine* ♀, March 11, 1899. In this and the two preceding figures the unilateral injury suggests an attack on the wing.

24. *Pyrameis cardui* ♂, Dec. 31, 1898.

EXPLANATION OF PLATE XII.

SEASONAL PHASES OF BUTTERFLIES OF THE GENUS *PRECIS*.

Representation of parent and offspring in *Precis sesamus* and *P. antilope*.

Demonstration of the seasonal phases of South African Butterflies of the genus *Precis*.

All the figures are about $\frac{9}{16}$ of the natural size.

All the specimens represented were captured or bred by Guy A. K. Marshall.

FIG. 1. *Precis sesamus*, form *natalensis* ♀, Salisbury, 5000 feet, captured Feb. 27, 1898, after it had laid three eggs. Parent of butterflies represented in Figs. 1a and 1b.

1a. *Precis sesamus* ♂, offspring No. 1 of butterfly represented in Fig. 1. Egg laid Feb. 27, hatched March 5, larva pupated March 31, imago emerged April 15.

1b. *Precis sesamus*, form *natalensis* ♀, offspring No. 2 of butterfly represented in Fig. 1. Egg laid Feb. 27, hatched March 5, larva pupated April 5, imago emerged April 20. A distinctly dark individual showing some slight tendency towards *sesamus*, especially in the width of the black margin of the hind-wings and the size of the blue spots in this margin.

These two offspring show the overlap of summer and winter phases remarkably well. The summer form, Fig. 1b, even appeared a few days later in the beginning of winter than the winter form, Fig. 1a. At the same time the former is unusually dark.

2. *Precis sesamus*, form *natalensis* ♀, Salisbury, 5000 feet, captured March 6, 1898, after it had laid one egg. Parent of butterfly represented in Fig. 2a.

2a. *Precis sesamus* ♂, offspring of butterfly represented in Fig. 2. Egg laid March 6, hatched March 12, larva pupated April 7, imago emerged April 30. The last part of larval

life and the first part of pupal were passed in a damp jar (March 30 to April 5). The imago is nevertheless a characteristic example of the dry phase.

- FIG. 3. *Precis antilope* ♀, form *simia*, Salisbury, 5000 feet, captured Feb. 23, 1902, after it had laid eleven eggs. Parent of butterflies represented in Figs 3*a* and 3*b*. The under-side is shown on Plate XIII, fig. 4.
- 3*a*. *Precis antilope* ♀, offspring No. 1 of butterfly represented in Fig. 3. Egg laid Feb. 23, hatched March 1, larva pupated April 10, imago emerged April 27. The under-side is shown on Plate XIII, fig. 4*a*.
- 3*b*. *Precis antilope* ♂, offspring No. 2 of butterfly represented in Fig. 3. Egg laid Feb. 23, hatched March 1, larva pupated April 14, imago emerged April 29. The under-side is shown on Plate XIII, fig. 4*b*.
4. *Precis archesia* ♀, captured Oct. 7, 1897, at Malvern, 800 feet, near Durban, Natal. This insect was *in coitu* with the form represented in Fig. 5.
5. *Precis archesia* ♂, a form varying somewhat distinctly in the direction of the wet phase (*pelasgis*), captured *in coitu* with the insect represented in Fig. 4. The tendency towards *pelasgis* is better shown upon the under-side, Plate XIII, fig. 8.

EXPLANATION OF PLATE XIII.

SEASONAL PHASES OF BUTTERFLIES OF THE GENUS *PRECIS*.

Under-sides of seasonal phases of *Precis sesamius*, *P. antilope*, and *P. archesia*, including those of *P. antilope* and its two offspring shown on Plate XII.

All the figures are about $\frac{2}{16}$ of the natural size.

All the specimens not otherwise described were captured by Guy A. K. Marshall.

- FIG. 1. *Precis sesamius*, form *natalensis* ♀, under-side of wings; Salisbury, 5000 feet, captured Feb. 20, 1898. Comparing this with Figs. 1, 1*b*, and 2 on Plate XII, it is seen that the under-side, although very similar to the upper, is even more conspicuous than it. The difference is brought about by the pale spots on the black basal patch of the

hind-wings and the more distinct white markings in the black marginal band, on the under-side; also by the paler tint of the ground-colour, making a stronger contrast with the black markings.

FIG. 2. *Precis sesamus* ♀, under-side of wings; Salisbury, 5000 feet, captured April 2, 1898. Even in the absence of colour the astounding difference between this and the wet-season phase (see Fig. 1) is clearly shown.

3. *Precis sesamus*, form *natalensis* ♂, strongly tending towards the dry phase, under-side of wings; Machakos, British East Africa, captured June 6, 1900, by Mr. and Mrs. S. L. Hinde. This beautiful variety stands well on the wet, or red, side of intermediate.
4. *Precis antilope*, form *simia* ♀, under-side of wings; Salisbury, Feb. 23, 1902. Parent of butterflies represented in Figs. 4a and 4b. This figure shows the under-side of the specimen represented in Fig. 3, Plate XII. It is seen that the under-side is much more conspicuous than the upper in the points mentioned above in the description of *P. sesamus*, form *natalensis* (Fig. 1); especially in the far greater contrast between the lighter ground-colour and the black markings and in the amount of white in the black border.
- 4a. *Precis antilope* ♀, under-side of wings. Offspring No. 1 of butterfly represented in Fig. 4. This figure shows the under-side of the butterfly represented in Fig. 3a, Plate XII. The difference between the under-side in offspring and parent is as astonishing as in the two phases of *sesamus*, while the difference in shape of the wings is even more remarkable.
- 4b. *Precis antilope* ♂, under-side of wings. Offspring No. 2 of butterfly represented in Fig. 4. This figure shows the under-side of the butterfly represented in Fig. 3b, Plate XII. The great difference in the character of the under-side in the two offspring (compare this figure with the preceding) is well shown, although both represent dead leaves equally well.
5. *Precis archesia*, form *pelasgis* ♂, under-side of wings; Salisbury, 5000 feet, captured Dec. 11, 1897. The figure shows well that the difference between the two phases of this species is far more important upon the under- than the upper-side. It is also seen that the pale, conspicuous, sharply-outlined, black-spotted band of the wet phase represents the intensely cryptic mid-rib-like streak of the

dry phase (compare this figure with Figs. 6, 7, and the somewhat intermediate Fig. 8).

- FIG. 6. *Precis archesia* ♂, under-side of wings; Salisbury, 5000 feet, captured April 30, 1899. The mottled browns and greys of the under-side are very markedly different from the uniform dark brown of the wet phase. Great variation in these mottled tints occurs in different individuals, harmonizing with the varied appearance of rocks, being at the same time dead-leaf-like.
7. *Precis archesia* ♀, under-side of wings; Berea, near Durban, Natal, captured April 5, 1896, by Mr. D. Chaplin. In this variety of *archesia* the ground-colour is comparatively unmottled, and to this extent transitional towards the *pelasgis* form. This difference upon the under-side corresponds with a slight approach in the same direction on the upper-side, where the deep red-brown band is broader and more continuous than is usual in typical *archesia*.
8. *Precis archesia* ♂, under-side of wings; variety distinctly transitional towards the *pelasgis* (wet) phase; Malvern, 800 feet, near Durban, Natal. This specimen was captured *in coitu* with a ♀ of typical *pelasgis*, Oct. 7, 1897. The intermediate character is seen in the conspicuous broad light band as well as in the unmottled ground-colour. Comparing this with Figs. 5 and 6, it is seen that in spite of this distinct tendency towards *pelasgis*, the specimen represented in Fig. 8 is still well on the *archesia* side of intermediate, and would doubtless be well concealed with its wings closed. The character of the surface of both wings outside the broad band is especially unlike *pelasgis*, as is the gradual transition of the outer border of the band itself into the ground-colour. The upper-side of the specimen here represented is shown on Plate XII, fig. 5, and that of the ♀ *pelasgis* with which it was *in coitu* on Plate XII, fig. 4.

EXPLANATION OF PLATE XIV.

MIMICRY IN MASHONALAND BUTTERFLIES.

Acræine and Lycænid mimics of *Limnas chrysippus*. Incipient mimicry of Acræas by *Lycænidae* and *Hesperidae*.

All the figures are about $\frac{3}{16}$ of the natural size.

All the specimens figured on this plate were captured by Guy A. K. Marshall in Mashonaland.

FIG. 1. *Limnas chrysippus* ♀, April 9, 1899. Captured together with the specimens represented in Figs. 1a, 2, and 2a at Salisbury (5000 feet). The specimen is rather small; the ground-colour is of the dark-brown shade characteristic of the Ethiopian Region.

1a. *L. chrysippus*, under-side ♂. The peculiar shade of the apex of the fore-wing beyond the sub-apical white bar much resembles the ground-colour of the hind-wing, but is distinguished from it by a faint greenish-orange tinge. It is seen to be mimicked in the under-side of *Mimacræa marshalli* (Fig. 2a), and less perfectly in that of *Acræa encedon* (Fig. 3a).

2. *Mimacræa marshalli* ♂. A beautiful mimic of *chrysippus* (compare Fig. 1). The shape of the sub-apical white bar however more strongly suggests that of *Acræa encedon* (Fig. 3).

2a. *M. marshalli*, under-side ♂. The spots at the base of the hind-wing as well as the shape of the sub-apical bar suggest *encedon* rather than *chrysippus* (compare Fig. 3a), although the mimicry of the latter is strong and evident.

3. *Acræa encedon* ♂, Dec. 1900. Captured together with the specimens represented in Figs. 3a, 4, 6, and 7 at Umtali (3700 feet). This, the typical form of the species, is seen to be synaposematic with *chrysippus*.

3a. *A. encedon*, under-side ♂. The under-side is seen to be synaposematic as well as the upper.

4. *Catochrysops peculiaris*, under-side ♂. The figure well shows incipient mimicry of the black-spotted under-side of an *Acræa*.

5. *C. mashuna*, under-side ♀, Nov. 7, 1897. Captured at the Umcheki River (4200 feet). The resemblance to an *Acræa* is closer in this species than in the

last, because of the pale tawny ground-colour of the under-side.

FIG. 6. *Abantis lettensis*, under-side. The under-side of the hind-wings shows strong mimicry of an *Acræoid* type.

7. *Kedestes macomo*, var., under-side. The under-side generally shows the incipient mimicry of an *Acræoid* type.

EXPLANATION OF PLATE XV.

BRITISH EAST AFRICAN BUTTERFLIES MIMICKING *L. CHRYSIPPUS*.

Acræine and *Lycænid* mimics of *Limnas chrysippus* form *klugii* in British East Africa. Varieties of *Acræa encedon* chiefly transitional towards the form *daira*.

All the figures are about $\frac{9}{16}$ of the natural size.

FIG. 1. *Limnas chrysippus*, form *klugii* ♂, May 22, 1900. Captured by Mr. and Mrs. S. L. Hinde, at Machakos Road, British East Africa (about 5400 feet). Very faint traces of the sub-apical white band of *chrysippus* can be detected.

1a. *L. chrysippus*, form *klugii*, under-side ♀, Oct., Nov. 1900. Collected by W. Doherty on the Kikuyu Escarpment, British East Africa (6500 to 9000 feet). Distinct traces of the sub-apical white band of *chrysippus* can be seen. Compare Fig. 1a, Plate XIV.

2. *Mimacræa dohertyi* ♀, Oct., Nov. 1900. Collected in the same locality as Fig. 1a, by W. Doherty. The position and outline of the costal part of the sub-apical white bar of *M. marshalli* can be distinctly traced in the contour of the black markings, although the bar itself is only very faintly paler than the fulvous ground-colour of the wing. Compare Fig. 2, Plate XIV.

2a. *M. dohertyi*, under-side ♂, Oct., Nov. 1900. Collected in the same locality as Fig. 1a, by W. Doherty. Traces of position of white bar as in upper-side; compare Fig 2a, Plate XIV. The black spots on the under-side of the under-wing resemble *Acræa encedon* (Fig. 3a) rather than the *Danaine* model of both insects (Fig. 1a).

3. *Acræa encedon*, form *daira* ♂, June 6, 1900. Captured by Mr. and Mrs. S. L. Hinde, at Machakos, British East Africa (about 5400 feet). Faint traces of the sub-apical

white bar of fore-wing although the black ground-colour of the apex is almost absent. Compare Figs. 4-7 and Fig. 3, Plate XIV.

- FIG. 3a. *A. encedon*, form *daira*, under-side ♂, Oct., Nov. 1900. Collected in the same locality as Fig. 1a, by W. Doherty. The under-side shows the same faint traces of the sub-apical white bar as the upper-side. Compare Fig. 3.
4. *A. encedon*, form *daira* ♂, Jan. 28, 1909. Captured by Mr. and Mrs. S. L. Hinde at Kitui, British East Africa (about 4000 feet). The sub-apical bar is rather more distinct and the surrounding ground-colour rather darker than in Fig. 3.
 5. *A. encedon*, intermediate between form *daira* and *encedon* ♂, May 18, 1900. Captured by Mrs. Leakey at Ndeje, Bulemezi, near Mengo, Uganda. In this interesting variety the sub-apical bar is very clearly defined by the greatly increased darkness of the adjacent ground-colour, and thus becomes very distinct, although it is itself of a darker shade than any of the specimens represented in the three previous figures (3, 3a, and 4).
 6. *A. encedon* tending towards the form *daira* in the darkness of the sub-apical bar, and towards the form *alcippina* in the whiteness of the inner part of the hind-wing ♂, May 19, 1900. Captured by Mrs. Leakey in the locality described in Fig. 5. The apex of the fore-wing would be that of typical *encedon* but for the darkness of the bar. It is noteworthy that the costal spot of the bar is much lighter than any of the other four component spots. On the under-side of this specimen the bar is much lighter, although not so white as in typical *encedon*.
 7. *A. encedon*, form *alcippina* ♂, Feb. 27 to March 2, 1900. Captured by Mrs. Leakey in the locality described in Fig. 5. With white, conspicuous hind-wings this variety closely resembles the form *alcippus* of *Limnas chrysippus*. The fore-wings are as in typical *encedon* except that they are somewhat darker than usual, suggesting, in the inner contour of the black patch, an approach towards the form *lycia*.

EXPLANATION OF PLATE XVI.

COMMON WARNING COLOURS OF MASHONALAND ACRÆINE
BUTTERFLIES, ETC.

All the figures are about $\frac{1}{10}$ of the natural size.

All the specimens represented on this Plate were captured by Guy A. K. Marshall at Salisbury, Mashonaland, 5000 feet.

FIG. 1. *Acraea doubledayi*, form *axina* ♂, Dec. 31, 1898.

2. " " " " ♀ " " "

3. " *caldarena* ♂, Dec. 31, 1898.

4. " " ♀ " " "

5. " *nohara*, form *halali* ♂, Dec. 31, 1898.

6. " " " " ♀ " " "

7. " *rahira* ♂, Dec. 31, 1898.

8. " " ♀ " " "

9. " *violarum*, form *asema* ♀, Dec. 31, 1898.

The above five species were therefore captured on the same day in the same place together with other examples of all species except *rahira*, as described on p. 492. The group is a beautiful example of synposematic (Müllerian) resemblance between the species of a specially-protected group inhabiting the same locality.

10. *A. anemosa* ♀, Jan. 7, 1899.

11. *A. natalica*, ♀ " "

A male of *anemosa* and a second female of *natalica* were captured on the same day. Another beautiful example of synposematic resemblance between two fine species.

12. *A. doubledayi*, form *axina* ♂, April 6, 1898.

13. *Baoris netopha* ♀, April 6, 1898.

The Hesperid at rest with its wings closed is a mimic of the smaller *Acraeas* such as that shown in Fig. 12. There are several white spots on both upper- and under-side of the fore-wing of the skipper, but these are concealed by the hind-wing in the position of rest with the fore-wings pressed well back between the hind. In the specimen figured the fore-wings are not quite sufficiently far back, so that the border of the dark shade which should be entirely concealed is exposed together with a part of the most anteriorly-placed white spot.

EXPLANATION OF PLATE XVII.

MIMICRY AND WARNING COLOURS IN COLEOPTERA.

Mutilloid Coleoptera: *Cleridæ*, *Carabidæ* and *Cicindelidæ*. Warning patterns in the Carabid genus *Anthia*.

All the figures are about $\frac{2}{3}$ of the natural size.

All the specimens, not otherwise described, were captured at the times mentioned, at Salisbury, Mashonaland, 5000 feet, by Guy A. K. Marshall.

FIG. 1. *Mutilla purpurata* ♂, Nov. 1898.

2. " *tettensis* ♀ " "
3. " *cephus* ♀ " "
4. " *leucopyga*? ♀ " "
5. " *sycorax* ♀ " "
6. " *horrída* ♀ " " to Jan. 1899.
7. *Atractonota mulsanti* " " Mimic of ant.
8. " " " " " "
9. *Polyhirma ænigma* " " " " and yet Mutilloid also.
10. *Polyhirma ænigma* " " to Jan. 1899. Mimic of large ant, and yet Mutilloid also.
11. *Eccopectera cupricollis*, Nov. 1898. A very perfect mimic of a *Mutilla*.
12. *Graptoclerus* sp., Nov. 1898. Mutilloid mimic.
13. *Polyhirma boucardi*, Nov. 1898 to Jan. 1899.
14. *Graphipterus antiokanus*, Nov. 1898 to Jan. 1899. Resembles the much larger Fig. 15, and, like it, Mutilloid.
15. *Piezia selousi*, Nov. 1898.
16. *Polyhirma bilunata*, Nov. 1898 to Jan. 1899. This and the last species, when running, bear a general resemblance to Mutillids.
17. *Myrmecoptera marshalli*, Nov. 1898.
18. " *invicta* " "
19. " *bilunata* " " This and the two previous species are mimics of Figs. 15, 16, etc.
20. *Myrmecoptera polyhirmoides*, var. *mashuna*, Nov. 1898 to Jan. 1899. A mimic of Fig. 13.
21. *Anthia massilicata*, Nov. 1898 to Jan. 1899.
22. " *petersi* " " " "
23. " *thoracica* " " " "

- FIG. 24. *Anthia sexguttata* ♀. Collected by Maj.-Gen. Hearsey, India.
 25. *Anthia nimrod* ♀. West Africa.
 26. " *omoplata*, var. *mellyi*, Nov. 1898 to Jan. 1899.

EXPLANATION OF PLATE XVIII.

MIMICRY IN MASHONALAND INSECTS.

Mashonaland insects of many Orders with Lycoid pattern and colouring: small groups probably mimetic of Ichneumonids.

All the figures are of the natural size.

All the specimens were captured by Guy A. K. Marshall, at the times mentioned, and unless otherwise described, at Salisbury, Mashonaland, 5000 feet.

Figs. 1 to 52 show a large and complex group, including species of the genus *Lycus* and insects of various Orders and numerous families mimetic of, or converging towards, the orange and black coloration of this abundant and distasteful genus.

FIG. 1. *Lycus* (*Merolycus*) *rostratus* ♂, Jan. 1899.

2. " " " ♀ " "
3. " (*Acantholycus*) *constrictus* ♂, Jan. 1899.
4. " *ampliatu*s ♂, June 1900.
5. " " ♀, Jan. 1899.
6. " (*Lopholycus*) *zonatus* ♀, Jan. 1899.
7. " (*Lopholycus*) *huagi* ♂ " "
8. " " " ♀ " "
9. " (*Chlamydolycus*) *subtrabeatus* ♂, Jan. 1899.
10. " " " ♀ " "
11. *Lycocerus* *mimicus* ♂, Nov. 1899.
12. " " ♀, Jan. 1899.
13. *Prionocerus* *dimidiatus*, Jan. 1899.
14. *Pæcilomorpha* *fasciaticollis*, Nov. 1900.
15. *Peploptera* *zambesiana*, Jan. 1899.
16. *Diacantha* *conifera* ♀, Nov. 1898.
17. " " ♂, Jan. 1899.
18. *Aphodius* *holubi*, Feb. 1899.
19. *Eutrapela* sp., Dec. 1901. Mt. Chirinda, Gazaland.
20. *Eletica* *rufa* ♂, Nov. 1898.
21. " " ♀ Jan. 1899.
22. *Mylabris* *palliat*a " "

- FIG. 23. *Zonitis* sp. Jan. 1899.
 24. *Blepisanis haroldi* " "
 25. *Amphidesmus analis* " "
 26. *Philagathes latus* ♂ " "
 27. " " ♀, Jan. 1902.
 28. *Nitocris* sp., Feb. 1900.
 29. " *nigricornis*? Dec. 1897.
 30. " *similis*, Jan. 1901.
 31. *Vitumnus scenicus*, var. *cinnabarinus*, Stål., Jan. 1899.
 32. " " " *miniatus*, Stål., Dec. 1900.
 33. *Serinettha mutilata*, April 1900.
 34. *Lygæus furcatus* " "
 35. *Oncopeltus famelicus*, var. *jucundus*, Sept. 1900.
 36. *Pompilus morosus* ♀, Jan. 1900.
 Asclepiad pollen masses are seen on the fore tarsi of both sides.
 37. *Pompilus capensis* ♀, Jan. 1899.
 38. " *diversus* ♀ " "
 39. " *vindex*, April 1900.
 40. *Cerceris orientalis*, var. ♀, Jan. 1899.
 41. *Notogonia cræsus* ♀, April 1900.
 42. *Rhynchium radiale* ♀, Jan. 1899.
 43. " *rubens* ♀, Jan. 1900.
 44. *Phanomeris* sp.? ♀, Jan. 1901.
 45. " " ♂, Feb. 1900.
 46. *Iphiaulax bicolor* ♀, Sept. 1900.
 47. *Bracon luctuosus* ♀, Aug. 1900.
 48. " ?*luctuosus* ♂, Jan. 1902.
 49. *Xiphocerus cruciger*, Jan. 1899.
 50. *Ilema elegans*, April 1900.
 51. *Zygænid* (gen. indet.). Mt. Chirinda, 4500 feet, Mashonaland, Dec. 1901.
 52. *Neurosymploca ochreipennis*, April 1900.
 Figs. 53 to 58 show the mimicry of three convergent and common Braconids by a Reduviid and a Longicorn.
 53. *Bracon coccineum* ♀, Aug. 1900.
 54. " " ♂, Nov. 1900.
 55. *Iphiaulax pictus* ♀, Aug. 1900.
 56. " *flagrator* ♀, Jan. 1899.
 57. *Oberca scutellaris*, Jan. 1899.
 58. *Callilestes bicolor* " "

The remaining figures exhibit a beautiful case of mimicry by a Reduviid of Synaposematic conspicuously marked parasitic Hymenoptera.

- FIG. 59. *Phanomeris dubius* ♀, Nov. 1900.
 60. *Pimpla tuberosa* ♂, April 1900.
 61. " " ♀, Nov. 1900.
 62. *Callilestes stigmatellus*, Nov. 1900.

EXPLANATION OF PLATE XIX.

MÜLLERIAN MIMICRY IN GROUPS OF SOUTH AFRICAN COLEOPTERA AND HEMIPTERA, ETC.

Figs. 30 to 38 twice the natural size; Figs. 53 to 59 one and a half times natural size; all other figures of the natural size.

All the specimens, except that shown in Fig. 16, were captured by Guy A. K. Marshall, and all, unless otherwise stated, are from Salisbury, Mashonaland, 5000 feet.

Figs. 1 to 16 represent a powerful group of *Cantharidae* and the insects convergent towards them, and having conspicuous cream, orange or red bands on a black ground. The group gradually merges into that shown in Figs. 17 to 29, in which the ground-colour is orange or yellow with black bands, sometimes broken up into spots.

- FIG. 1. *Mylabris dicincta*, Dec. 1898.
 2. " *tettensis*, Nov. 1898 to Jan. 1899.
 3. " " Dec. 1898.
 4. " *tricolor*, Nov. 1898 to Jan. 1899.
 5. " *oculata* " " "
 6. " " Dec. 1898.
 7. *Actenodia chrysomelina*, Dec. 1898.
 8. " " Nov. 1898.
 9. *Mylabris holosericea*, Dec. 1898.
 10. *Decatomia lunata*, Nov. 1898 to Jan. 1899.
 11. *Actenodia chrysomelina*, Dec. 1900.
 12. *Decatomia lunata*, var., Nov. 1898 to Jan. 1899.
 13. *Mylabris oculata* " " " "
 14. *Cymatura bifasciata*, Dec. 1898.
 15. *Ceroplesis caffer*, Dec. 1898.
 16. *Anubis mellyi*, Colenso, Natal.
 17. *Oncopeltus famelicus*, Sept. 1900.
 18. *Melitonoma* n. sp., Dec. 1898.
 19. " *truncatifrons*, Oct. 1901.
 20. *Clythra wahlbergi*, Dec. 1898.
 21. *Melitonoma litigiosa*, Jan. 1901.

- FIG. 22. *Antipus rufus* ♀, Oct. 1901.
 23. *Melitonoma epistomalis*, Oct. 1901.
 24. *Clythra lacordairei*, Oct. 1901.
 25. *Antipus rufus* ♀, Feb. 1899.
 26. *Aulacophora festiva*, Oct. 1901.
 27. *Cryptocephalus quinqueplagiatus*, Dec. 1900.
 28. " *varioplagiatus*, Oct. 1901.
 29. *Syagrus marshalli*, Sept. 1900.

Figs. 30 to 38 show a very well-defined group of small Coleoptera in which the head and thorax are bright red and elytra creamy-white with transverse black bands or spots.

30. *Platyxantha bicincta*, × 2, Jan. 1899.
 31. *Gynandrophthalma posticalis* ?, × 2, Feb. 1899.
 32. *Monolepta vincta* ?, × 2, Jan. 1899.
 33. *Crioceris coronata* " " "
 34. *Paralepta ornata* " " "
 35. *Asbecesta* " " "
 36. *Urodactylus* sp. ♂ " " "
 37. " " ♀ " " "
 38. *Apoderus gentilis* " Nov. 1898.

Figs. 39 to 42 show a convergent group of an Hemipteron and two Coccinellids with the characteristic red or yellow and black spotted coloration of the latter family.

39. *Steganocerus multipunctatus*, Feb. 1899.
 40. *Epilachna dregei*, Nov. 1898.
 41. " " Feb. 1899.
 42. *Chilomenes lunata*, Feb. 1899.

Figs. 43 to 47 represent a convergent group of red and black coloured Hemiptera—a Reduviid mimicking Lygaeids.

43. *Reduvius* sp., Jan. 1900.
 44. *Lygæus rivularis*, Nov. 1899.
 45. *Graphostethus servus*, Feb. 1900.
 46. *Lygæus elegans*, Feb. 1900.
 47. " *crudelis*, Jan. 1900.

Another Hemipterous group showing Reduviids mimicking Pyrrhocorids is shown in Figs. 48 to 52.

48. *Phonoctonus nigro-fasciatus*, Oct. 1897, Malvern, near Durban, Natal.
 49. *Dysdercus nigro-fasciatus*, Oct. 1897, Malvern, near Durban, Natal.
 50. *Dysdercus superstitiosus*, April 1900.
 51. " *intermedius*, Feb. 1900.
 52. *Phonoctonus formosus*, Feb. 1900.

The remaining figures represent a group containing a Locustid and an Hemipteron mimetic of ants.

- FIG. 53. *Camponotus* sp.? ♀ × $1\frac{1}{2}$, Feb. 17, 1901.
 54. „ *sericeus*, ♀ × $1\frac{1}{2}$, Feb. 17, 1901.
 55. „ *cosmicus*, ♀ min. × $1\frac{1}{2}$, Feb. 17, 1901.
 56. „ „ ♀ maj. „ „ „
 57. *Megapetus atratus*, × $1\frac{1}{2}$, Feb. 17, 1901.
 58. „ „ „ „ „
 59. *Myrmecophana*? *fallax*, × $1\frac{1}{2}$, Feb. 17, 1901.

EXPLANATION OF PLATE XX.

GROUP OF BLACK, DARK-WINGED MASHONALAND ACULEATES AND THEIR MIMICS.

FIRST PART OF GROUP.

The Aculeates with one exception all Fossores.

All the figures are about $\frac{1}{2}$ of the natural size.

All the specimens were captured by Guy A. K. Marshall, at Salisbury, Mashonaland, 5000 feet.

- FIG. 1. *Mutilla atropos* ♂, Nov. 1899.
 2. *Tiphia rugosa* ♀, Feb. 1899.
 3. *Elis lachesis* ♀, April 1900.
 4. „ *fasciatipectennis* ♀, April 1900.
 5. „ „ ♀, Feb. „
 6. *Scolia alaris* ♂, April 1900.
 7. „ „ ♀, Mar. „
 8. „ „ ♀, April „
 9. „ *fraterna* ♂, Jan. „
 10. „ „ ♀, April „
 11. „ *cyanea* ♂, Jan. „
 12. „ „ ♀, Mar. „
 13. „ *affinis* ♂, June „
 14. *Salix atropos* ♀, Mar. „
 15. „ *rindex* ♀, Nov. 1899.
 16. „ *dedjax* ♂, Feb. 1899 to Jan. 1900.
 17. „ *regina* ♂, Feb. 1899.
 18. „ *obscurus* ♀, Dec. 1899.
 19. *Pompilus sepulchralis* ♀, April 1900.
 20. „ *frustratus* ♀, Nov. 1899.

- FIG. 21. *Orectocera (Paraphania) diabolus*, Feb. 1900.
 22. *Exoprosopa umbrosa*, Feb. 1900.
 23. *Orectocera (Paraphania) diabolus*, Jan. 1900.
 24. *Tabanus*, very near *biguttatus*, Dec. 1900.
 25. *Tascia homochroa*, Dec. 1900.
 26. *Reduvius*, sp., April 1900.
 27. *Harpactor tristis*, April 1900.

EXPLANATION OF PLATE XXI.

GROUP OF BLACK, DARK-WINGED MASHONALAND ACULEATES
 CHIEFLY FOSSORES, AND THEIR MIMICS, ETC.

SECOND PART OF GROUP, CHIEFLY FOSSORES.

All the figures are about $\frac{1}{2}$ of the natural size.

All the specimens were captured by Guy A. K. Marshall, at Salisbury, Mashonaland, 5000 feet.

- FIG. 1. *Sphex bohemani* ♀, Dec. 1899.
 2. " " ♂, Jan. 1900.
 3. " *cyaniventris* ♂, Nov. 1899.
 4. " *pelopeiformis* ♂, Jan. 1900.
 5. " " ♀, June "
 6. " *xanthocerus* ♀, Dec. 1899. An Asclepiad pollen-mass is seen on distal end of the left anterior leg.
 7. *Sphex umbrosus* ♀, May 1900.
 8. *Sceliphron chalybeum* ♂, Feb. 1900.
 9. *Tachytes natalensis* ♂, Jan. 1900.
 10. " " ♀, Dec. 1899.
 11. *Ammophila ludovicus* ♀, Feb. 1899 to Jan. 1900. Asclepiad pollen-masses are thickly crowded on the tarsi of the two anterior pairs of legs.
 12. *Ammophila ludovicus* ♂, June 1900.
 13. " *beniniensis*, ♀, Jan. 1900.
 14. *Eumenes tinctor* ♂, Dec. 1899.
 15. " " ♀, " "
 16. " *dyschera* ♂, Feb. 1900.
 17. " " ♀, Nov. 1899.
 18. *Xylocopa hottentotta* ♀, Jan. 1900.
 19. " *carinata* ♀, Feb. 1899 to Jan. 1900.

- FIG. 20. *Laparus* sp., Jan. 1900.
 21. „ ? *tabidus*, Feb. 1900.
 22. *Trymodera aterrima*, Nov. 1898 to Jan. 1899.
 23. *Epicauta pectoralis*, Nov. 1898 to Jan. 1899.
 24. „ *subcoriacea* „ „ „ „
 25. „ *caelestina*, Feb. 1900.
 26. „ „ or *subcoriacea*, Nov. 1898 to Jan. 1899.
 27. *Lytta moesta*, Nov. 1898 to Jan. 1899.
 The following figures represent a beautiful little group of species of *Megachile* and their mimics.
 28. *Megachile nasalis* ♀, Nov. 1899.
 29. „ *chrysorrhæa* ♀, Jan. 1900.
 30. *Celioxys pusilla* ♂, Dec. 1899. Probably parasitic on one of the two former species.
 31. *Laphria* sp., near *flavipes*, Feb. 1900.

EXPLANATION OF PLATE XXII.

GROUP OF YELLOW-TAILED, BLACK MASHONALAND ACULEATES,
 ALMOST ENTIRELY DIPLOPTERA, AND THEIR MIMICS. A XYLO-
 COPID AND ITS ASILID MIMIC.

All the figures are about $\frac{1}{2}$ of the natural size.

All the specimens were captured by Guy A. K. Marshall, and all, except those otherwise described, are from Salisbury, Mashonaland, 5000 feet.

- FIG. 1. *Scolia erythropyga* ♂, Dec. 1899.
 2. „ „ ♀, April 1900.
 3. *Salix tamisieri* ♂, Mar. 1900.
 4. „ „ ♀, Nov. 1899.
 5. „ *spectrum* ♂, Jan. 1900.
 6. *Rhynchium synagroides* ♂, Feb. 1900.
 7. *Synagris abyssinica*, var. ♀, Umtali, 3700 feet, Dec. 1900.
 8. „ *mirabilis* ♀, April 1899.
 9. „ *emarginata* ♀, Mar. 1900.
 10. „ *analis* ♀, Umtali, 3700 feet, Dec. 1900.
 11. „ „ ♂, Dec. 1899.
 12. „ *xanthura* ♀, Jan. 1900.
 13. „ *emarginata* ♂, April 1900.

- FIG. 14. *Eumenes dyschera* ♂, Jan. 1900.
 15. *Trochilium* sp. , Umtali, 3700 feet, Dec. 1900.
 16. " " " " "
 17. *Bombylius* sp. nov., Feb. 1900.
 18. *Silvius pertusus*, Nov. 1898.
 The two remaining figures illustrate the mimicry of a large
 Asilid fly for a common type of African Xylocopid bee.
 19. *Xylocopa flavo-rufa* ♀, Oct. 1899.
 20. *Hyperochia marshalli* ♂, Feb. 1899. Mimic of the above.

EXPLANATION OF PLATE XXIII.

MASHONALAND ACULEATES AND THEIR MIMICS.

All the figures are about $\frac{1}{10}$ of the natural size.

All the specimens were captured by Guy A. K. Marshall at Salisbury, Mashonaland, 5000 feet.

Figs. 1 to 11 are a group of small insects with black head and thorax and yellow or fulvous abdomen.

- FIG. 1. *Elis aureola* ♀, April 1900.
 2. *Philanthus fuscipennis* ♀, Feb. 1900.
 3. " *diadema* ♀, Oct. 1899.
 4. " " ♂, Jan. 1900.
 5. " *brucephalus* ♂, Feb. 1900.
 6. *Rhynchium radiale* ♀, Jan. 1899.
 7. " *rubens*, var. ♀, Jan. 1899.
 8. " " var. ♀, Feb. 1900.
 9. *Sphecodes rufiventris* ♀, April 1899.
 10. *Chalcis bicolor* ♂, April 1900.
 11. *Athalia bicolor*, Jan. 1900.

The two following figures represent outlying members of the group represented in Figs. 14 to 19, the colour of the head and thorax being of a darker tint.

12. *Xylocopa lateritia* ♀, Jan. 1900.
 13. " *flavo-rufa* ♀, Oct. 1899.

Figs. 14 to 19 are black, dark-winged insects with yellowish head and thorax.

14. *Podalirius acraënsis* ♀, May 1899.
 15. *Anthophora basalis*? ♀, Oct. 1899.
 16. *Xylocopa olivacea* ♀, June 1900.
 17. " *modesta* ♀ " "

Fig. 18. *Elis caelebs* ♀, Dec. 16, 1900.

19. *Melittia* sp. " " Mimic of the above.

Figs. 20 to 29 and 31 are insects with dark-blue or blackish wings and yellow heads. Where the anterior yellow is most developed (as in Fig. 25) the group merges into the preceding one; where it is least, the convergence is towards the blue-winged group shown on Plates XX and XXI.

20. *Pompilus marshalli* ♀, Oct. 1899.

21. " *dichrous* ♂, Jan. 1900.

22. " " ♀, Oct. 1899.

23. " *lascivus* ♀, June 1900.

24. " *anticus* ♀, Jan. 1900.

25. *Salix tamisieri* ♀, Feb. 1899.

26. *Tachysphex fluctuatus* ♀, June 1900.

27. *Bromophila caffra*, Dec. 1899.

28. *Jonthodes sculptilis*, Nov. 1898 to Jan. 1899.

29. *Eletica rufa* ♂, Nov. 1898 to Jan. 1899.

Figs. 30, 32, and 33 are blue- or black-winged insects with yellow-banded legs which are very conspicuous during flight.

30. *Litopus dispar*, Feb. 1899.

31. *Iphiaulax ruber* ♀, Oct. 1900.

32. *Osprynchotus flavipes* ♀, Jan. 1900.

33. *Pirates æneicollis*, Dec. 1900.

Figs. 34 to 36 are black insects with narrow yellow bands and clear wings.

34. *Pompilus festivus* ♀, Jan. 1899.

35. *Myzine capitata* ♂ " "

36. *Metopius discolor* ♂ " "

Two flies with their model a *Megachile* bee.

37. *Megachile apiformis* ♂, Jan. 1899.

38. *Eumerus* sp. nov. ? " "

39. *Laxenecera mollis*, Mar. 1900.

The following figures represent a Syrphid fly which closely mimics a common social wasp.

40. *Polistes marginalis* ♀, Dec. 1898.

41. *Ceria gambiana* " "

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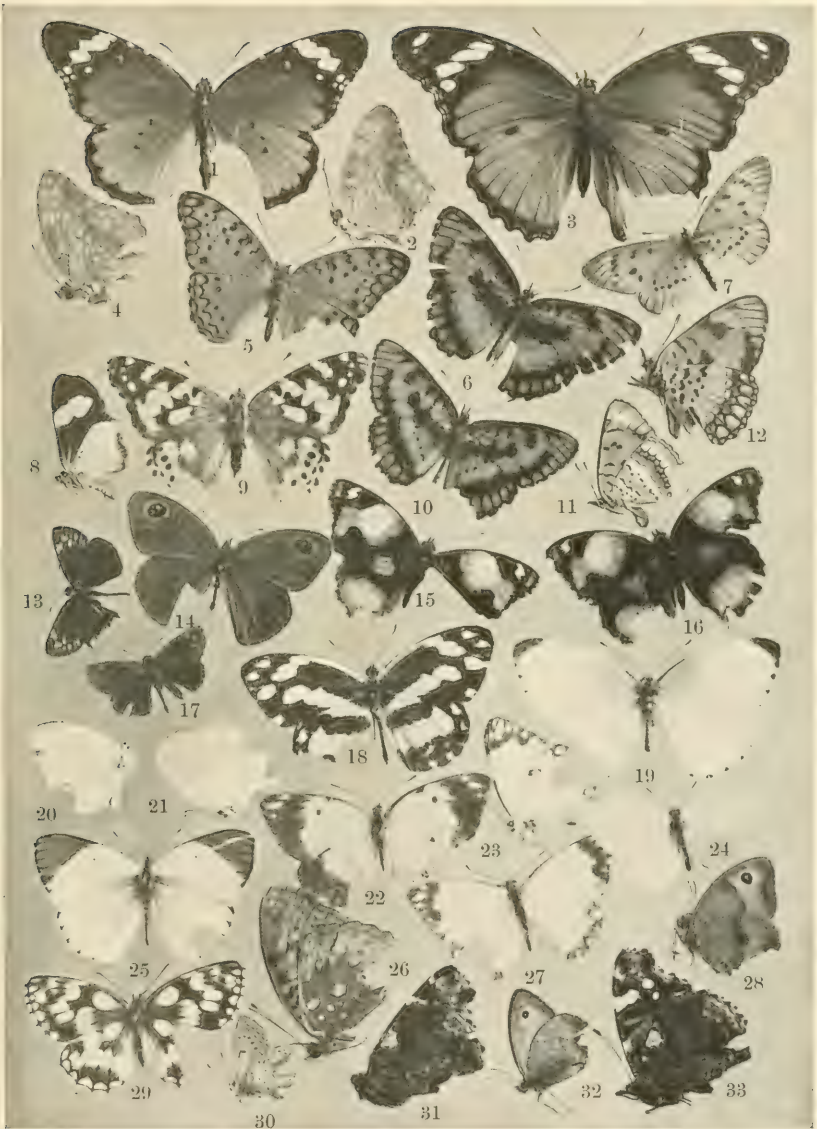


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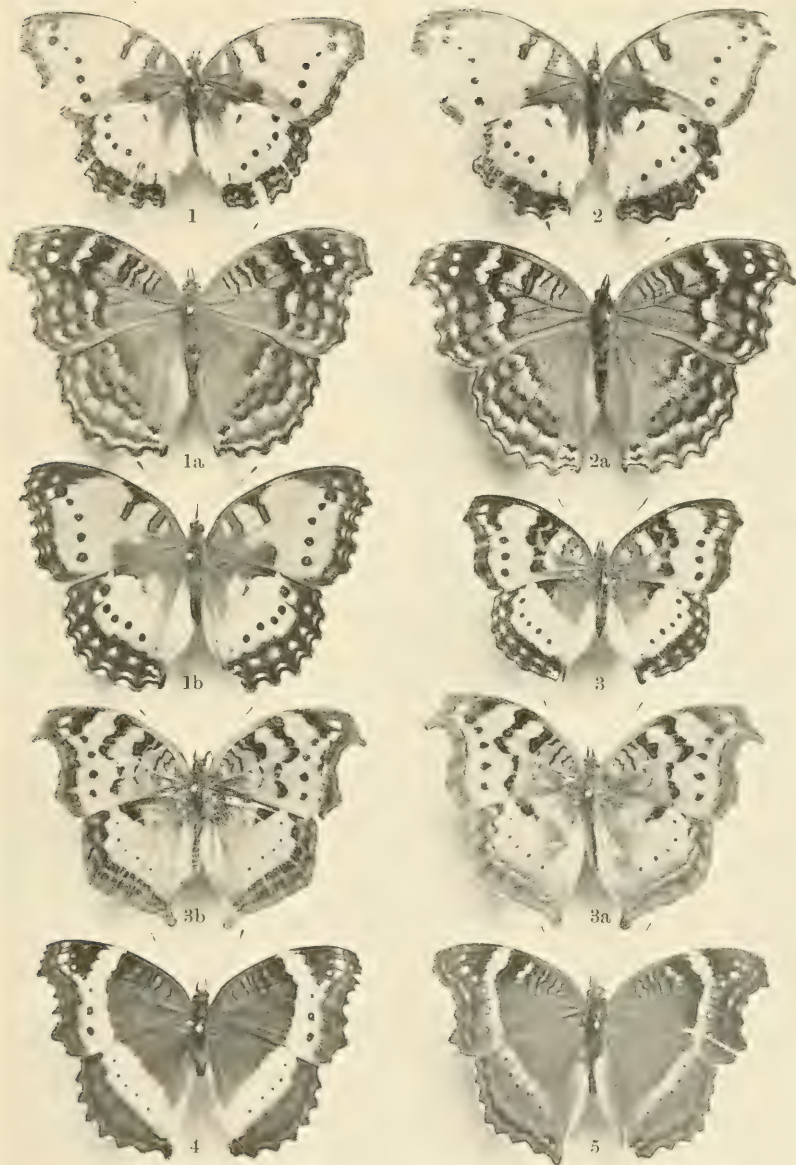


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Mashonaland Butterflies mimicking *L. chrysippus* and *Acraeas*.

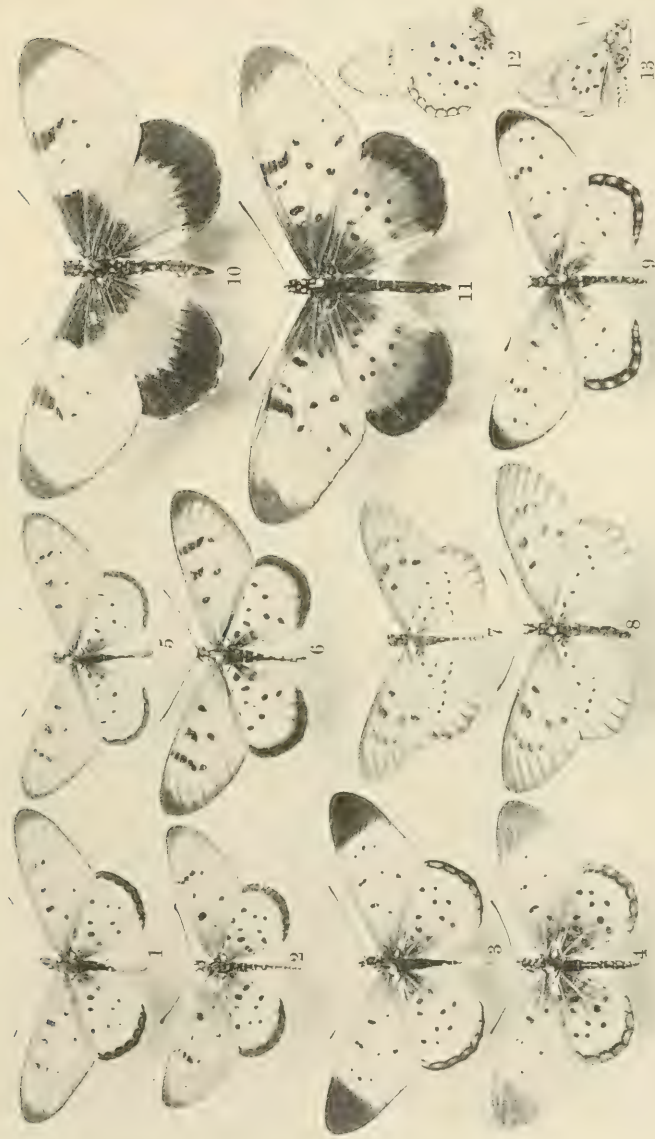


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Common Warming Colours of Mashonaland Acraeina Butterflies, &c.

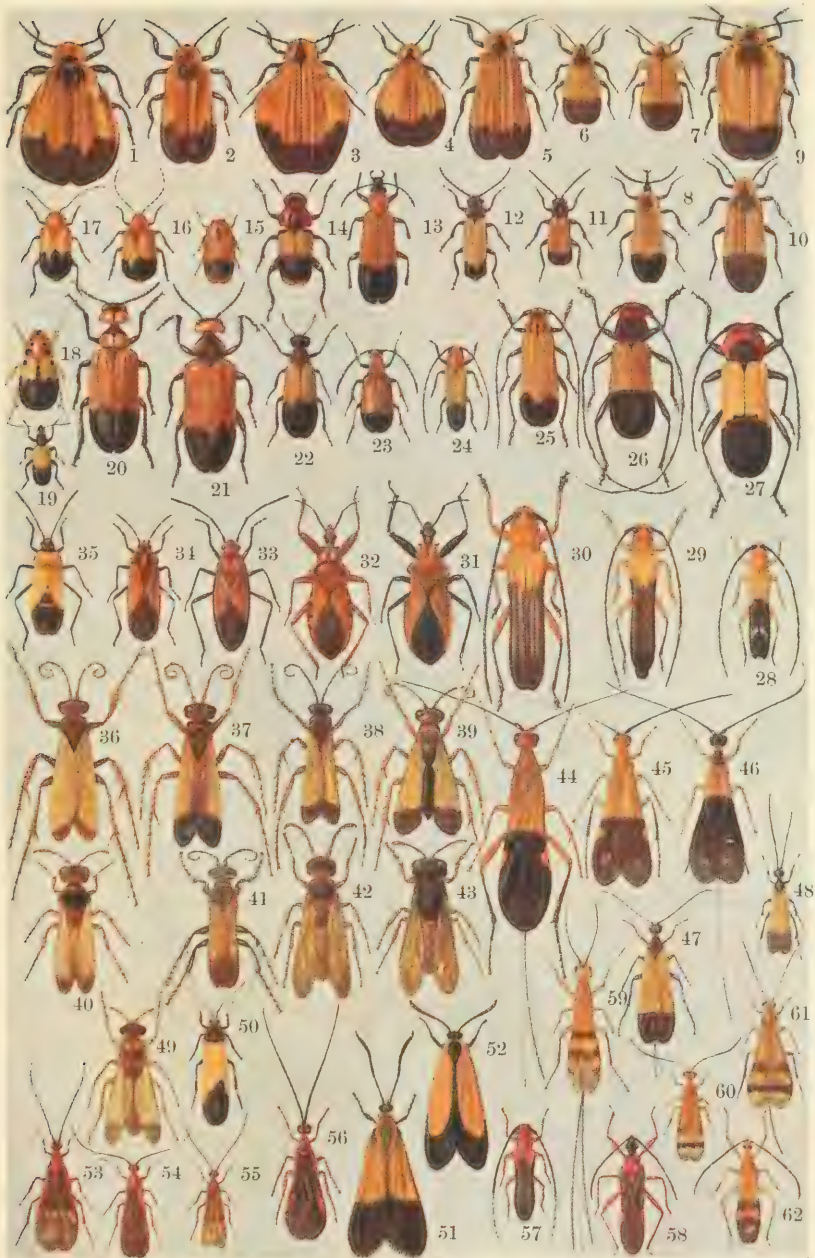


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Warning patterns and Mimicry of Mutillidæ in Carabidæ.
and Cicindelidæ, &c.



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**Mashonaland Insects of many Orders with Lycoid pattern
and colouring, &c.**



G. A. K. Marshall.

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Figs. 30-38 are twice the natural size.
 Figs. 53-59 are $1\frac{1}{2}$ times the natural size.
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Müllerian Mimicry in South African Beetles, &c.



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Group of black, dark-winged, Mashonaland Aculeates and
their Mimics. First part of Group.



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Group of black, dark-winged Mashonaland Aculeates and their Mimics. Second part of Group.



G. A. K. Marshall.

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All the figures are about $\frac{1}{3}$ of the natural size.

Group of yellow-tailed, black, South African Aculeates and their mimics.



G. A. K. Marshall.

André & Sleight, Limited.

All the figures are about $\frac{9}{10}$ of the natural size.

South African Aculeates and their Mimics.

March 5th, 1902.

Papers, etc., read.

Prof. E. B. POULTON, F.R.S., gave an account of a paper by Mr. Guy A. K. Marshall, entitled "Five years' (1896-1901) Observations and Experiments on the Bionomics of South African insects, chiefly directed to the Investigation of Mimicry and Warning Colours, with an Appendix containing Descriptions of New Species by Colonel C. T. Bingham and Mr. W. L. Distant." The paper not only contained Mr. Marshall's account of his researches, but the unrecorded notes of many other naturalists bearing on the same subjects, together with numerous quotations from Mr. Marshall's letters to Prof. Poulton and the full description of a large number of specimens illustrating insect bionomics sent by him to the Hope Collection at Oxford. These latter will be permanently retained in the bionomic section of the Collection, where they can be studied by any naturalist visiting Oxford. Perhaps the most important part of the memoir consists of a full description of the long series of observations and experiments, conducted, with great care, upon South African insect-eating animals. The insect enemies made use of were spiders, *Mantidæ*, lizards, frogs, kestrels, the Ground Horn-bill, the Mongoose, and the Baboon. Exact observations of birds in the wild state capturing butterflies are also added, together with a statement of the insects, etc., found in the digestive canal of birds, and numerous specimens of butterflies which, from the character of the injuries received, appear to have been attacked by enemies. The experiments on the *Mantidæ* are of the highest importance, several genera being made use of, and the researches continued for many weeks or even months in the case of certain species. These predaceous insects freely devoured such forms as *Mylothris* and often even *Limnas chrysippus*, while the *Acræinæ* were evidently distasteful to them. Some of the series of experiments rendered it probable that *Acræinæ* are poisonous, or at least unwholesome food to the *Mantidæ*. The experiments on kestrels and baboons were also very numerous and important. As regards the Lepidoptera the support afforded to the theories

of warning colours and mimicry was very striking. Another feature was the great use made of Coleoptera and the strong witness to the distastefulness of the conspicuous groups, such as the *Lycidæ*, *Melyridæ*, *Cantharidæ*, etc. As a result of these experiments and the work of other naturalists, the attempt is made to draw up a list of the Coleopterous groups which correspond to the Rhopalocerous *Ithomiinæ*, *Danainæ*, *Heliconinæ* and *Acræinæ*. The chief of these are the conspicuous, convergent, frequently mimicked and presumably distasteful *Erotylidæ*, *Endomychidæ*, *Malacodermidæ*, *Melyridæ*, *Coccinellidæ*, *Cantharidæ*, and *Chrysomelidæ*.

The memoir also contains the evidence produced by Mr. Marshall in refutation of Haase's conclusion that conspicuous specially defended butterflies are not attacked by insect parasites. The conclusion of Profs. Plateau and Wheeler that human experience of the taste of insects affords trustworthy evidence of their effect upon the senses of insectivorous animals is examined in the light of Mr. Marshall's experiments and found to be unsound.

The remarkable mimicry of Curculios with a cryptic colouring by Longicorns is discussed, and the conclusion reached that the defence provided by such a quality as hardness does not appeal like distastefulness to many classes of enemies irrespective of size, and that the concealment afforded by protective resemblance is necessary against the considerable number of foes which are strong enough or large enough to attack successfully.

The mimetic resemblance of *Mantispidæ* to Hymenoptera, already recognized in North America (Wheeler) and Borneo (Shelford), is further illustrated by a fine example from South Africa. The use of insect stridulation as a means of warning or intimidation is discussed. The experimental evidence of the value of the terrifying markings and attitudes of *Chærocampa* larvæ is strengthened by the remarkable impression produced by an African species upon a pair of baboons. As bearing on this section it is shown that *Chærocampa elpenor* is still an object of superstitious dread in Ireland. The shorter notes deal with such subjects as "The courtship of *Limnas chrysippus*," "The meaning of the sac of female *Acræinæ*," "A

Rhodesian Muscid fly parasitic on man," "Evidence of terror caused by the squeak of *A. atropos*," etc.

The material described in the paper illustrates many varied aspects of mimicry, warning colours, and common warning colours from the points of view provided by several very diverse orders of insects. The most striking contribution to the subject is probably the remarkable group of synaposematic insects with a Lycoid colouring (fulvous and black), and the varied assemblages which are made up by Hymenoptera Aculeata with well-marked types of colouring, each being attended by insects of other orders, many of which are undoubtedly Müllerian components, while others may be Batesian, although the latter interpretation can only be accepted as probable in a very small proportion of the examples. Among these groups perhaps the most important consists of insects which are entirely black with iridescent blue-black wings. No less than twenty-eight convergent species of Aculeates form the centre of an assemblage, round the periphery of which are scattered Hemiptera, Diptera, Coleoptera (*Cantharidæ*), with a single Zygaenid moth. In another group of almost equal importance the colouring is similar to the last, except that the posterior end of the abdomen is bright yellow or orange. In another the whole abdomen is yellow, and the wings transparent: another is similar to the first described Aculeate-centred group, except that the head is red: another differs in having a yellowish head, thorax, etc. Not only the Aculeates but other specially protected South African insects sent by Mr. Marshall form beautiful synaposematic groups, sometimes included within the limits of a single order, sometimes attracting insects of other orders. Thus one group of conspicuous little beetles consisted of six species of Phytophaga, belonging to six genera, at least one Melyrid, and a Curculionid. The black-and-orange banded Cantharid type comprises many species, and a few different genera of these Coleoptera, together with two Longicorns, two Phytophagous beetles and a Hemipteron, make up a strong and characteristically marked combination. The Hemiptera form well-marked and apparently self-contained groups, one with a conspicuous pattern of black and red with a black membrane, or a white membrane through which

the black body is more or less clearly seen; another pale yellow with black transverse bars. The first of these groups is composed of Lygæid and Reduviid species, the second of Pyrrhocorid and Reduviid. To return to the Aculeate-centred groups, the *Mutillidæ* are resembled by *Carabidæ* and *Cicindelidæ*, and yet there is also a secondary resemblance between these two latter, which becomes primary in the case of species which do not resemble the *Mutillidæ*. In other cases small slender *Carabidæ* of the genus *Atractonota* primarily resemble ants in movement and appearance, and yet secondarily resemble other species of *Carabidæ* in the markings by which these latter resemble the *Mutillidæ*. These complex inter-relationships suggest proto-, deutero-, and perhaps trito-synaposematic resemblances for the Müllerian associations, proto-, deutero-, and perhaps, tritopseudaposematic resemblances for the Batesian.

Another important group has for its centre three species of ants, resembled by a Pyrrhocorid bug of a new genus, *Megapetus*, described by Mr. Distant in the Appendix, and a little Locustid of the genus *Myrmecophana*, with the parts of the body which would interfere with the likeness to an ant obliterated, upon the plant on which the insect occurs, by their green colour. Examples of all these were taken on one plant in a single day.

Nearly all groups here shortly described were illustrated by photographs projected on the screen. A brief account of some of the chief results of Mr. Marshall's work was read before Section D of the British Association at Bradford (1900), and published in abstract in *The Report* (p. 793).

The number of new facts is so large, the experiments so numerous and complete, and the range of observation extended over so many orders in addition to the usually-studied Lepidoptera, that this memoir places South Africa in the first rank as the country from which the chief evidence in support of existing theories of Mimicry, Warning Colours, etc., has been supplied.

A discussion ensued in which Mr. F. Merrifield, Dr. F. A. Dixey, Prof. Hudson Beare, Colonel Yerbury, Mr. J. W. Tutt, and Prof. Poulton took part.

XX. *The Protective Resemblance to flowers borne by an African Homopterous Insect, Flata nigrocincta*, Walker. By SIDNEY LANGFORD HINDE. Communicated by Prof. EDWARD B. POULTON, M.A., D.Sc., F.R.S.

[Read June 4th, 1902.]

PLATES XXVI AND XXVII.

THE "cluster of insects grouped to resemble a flower spike" which forms the frontispiece of Professor J. W. Gregory's "Great Rift Valley" (London, 1896) has attracted much attention and interest, as well as a certain amount of criticism. As I have had many opportunities of seeing the insect, and still oftener its larvæ, in the wild state, in British East Africa, and have drawings of both *in situ* made upon the spot by my wife, it seems desirable to publish the evidence.

Professor Gregory's plate was apparently drawn in England from his description and the dried specimens. In the insects grouped on the vertical stem the green individuals occupying the uppermost position (Fig. 1) are represented as considerably smaller than the red ones below, like the unopened green buds towards the top of a flowering spike as compared with the expanded blossoms below. On the other hand, the separate representations of the green (Fig. 3) and red forms (Fig. 2) of the insect, as well as the description on pages 273-275 of the work, indicate that there is no difference in size between the two. My own experience entirely confirms this latter conclusion, and there is no doubt that the impression conveyed by Fig. 1 is in this respect erroneous. Furthermore, the uniform deep pink colour of the exposed parts of the insects represented in Figs. 1 and 2 of the frontispiece is incorrect. The colours of the red forms of the living insect are as shown on the accompanying Plate XXVI, being of a bright orange-red anteriorly passing into a reddish-orange over the remainder of the surface exposed in the attitude of rest.

Furthermore, I have never seen the insects grouped according to their colours, but invariably mixed; I have

never seen the larvæ and imagines on the same stem or even together on the same tree or bush. I have never seen the imagines on vertical stems, but always on those which are actually or approximately horizontal.

It does not by any means follow that Professor Gregory was mistaken in his impressions, but it is certain that conditions other than those which he records are common. The discrepancy is not, however, to be explained by the hypothesis that I have been observing one species and Professor Gregory another. My material has been compared with that of Professor Gregory in the British Museum of Natural History by Professor Poulton, and he states both sets of specimens certainly belong to the same species, viz. a form slightly different from *Flata nigrocincta* (Walker), but evidently closely allied and perhaps specifically identical with it.

One criticism of Professor Gregory's plate and description we cannot sustain. I understand that the experienced African naturalist, Mr. W. L. Distant, holds that the position shown in Professor Gregory's Fig. 1 was merely due to the heavy rain which is stated to have occurred at the time (*loc. cit.*, p. 273), the insects having crept up the vertical stem to as great a height as possible in order to escape the wet. Mr. Distant accordingly believes that their grouping is unconnected with any protective resemblance to an inflorescence. My wife and I, on the other hand, recognize a strong superficial likeness between the mixed groups of insects and the flowers and buds of a leguminous plant with which we are perfectly familiar. We have mistaken the groups of insects for the flowers, and conversely the flowers for the insects. We unfortunately omitted to bring a piece of the plant to England in order that it may be identified, but this omission can easily be rectified on our return to East Africa.

Although, as I have said, we have never seen the imagines on vertical stems, the groups of larvæ were generally, although not always, in this position, as may be seen on Plate XXVII, reproduced about two-thirds of the natural size from a drawing made and finished upon the spot by Mrs. Hinde (Jan. 20, 1901). The locality was an island in the Athi River near the "Falls," about twenty-three miles from Kitui Station. There were dozens of groups on the shrubs and small trees under the shade of large trees on the island, and the group painted—a small

one—was that which was most convenient in position, about four feet from the ground. The long wax filaments so easily break that it was impossible to obtain satisfactory results by painting the captured larvæ.

The drawing of the imagines was made Jan. 23, 1901, at Kitui Station, from a branch of a bush which was covered with groups and single insects, although in both larvæ and imagines these latter are rare as compared with groups. The bush, which was small, was about fifteen feet high and ten feet in diameter.

When disturbed the imagines fly and the larvæ hop a short distance in any direction, but they soon begin to collect in groups again: the larvæ will have reformed into small groups in half-an-hour. The larvæ are often seen on rotten wood and dead leaves, but this is probably after they have been disturbed. Frequently too, I have seen the waxy secretion left adhering to branches where they have been. The larvæ seem to prefer a moist atmosphere and shade, although I have seen them in the broadest sunshine at Kibwezi, the locality where the insects were seen by Professor Gregory. The imagines I have observed in numbers on three or four occasions and in single groups several times. The groups of larvæ are usually about three or four inches in length, but I have seen a group as much as two feet long.

The larvæ towards the growing end of a branch are the smallest of the group (see Plate XXVII), and Professor Poulton suggests that this observation may perhaps reconcile Professor Gregory's account with ours. Professor Gregory, indeed, considers that the eggs of the *Flata* are laid from below upwards so that the insects towards the top of the stem would be the younger, and he thinks possibly immature (*loc. cit.*, p. 275). But the difference in colour cannot be due to immaturity, for we have found old, worn specimens of the green form. The first to emerge of any group may, however, be green, and those that emerge later red; and Professor Gregory may have come across undisturbed groups which therefore were green above and red below. Our groups, on the other hand, may have reassembled, and thus have lost the arrangement which it is possible they may have possessed on emergence from the pupal state. Specimens of larvæ and imagines captured at the time when the sketches were made were sent by us to the Hope Collection at Oxford.

EXPLANATION OF PLATE XXVI.

PROTECTIVE RESEMBLANCE TO FLOWERS OF BRITISH EAST AFRICAN FLATA NIGROCINCTA (WALK.).

About $\frac{2}{3}$ of the natural size.

The sketch was made by Mrs. S. L. Hinde at Kitui on Jan. 23, 1901, and represents an actual group painted *in situ*. A red and a green form of imago are shown separately with their wings expanded. The Plate is a three-colour reproduction of the original painting.

EXPLANATION OF PLATE XXVII.

LARVÆ OF BRITISH EAST AFRICAN FLATA NIGROCINCTA (WALK.).

About $\frac{2}{3}$ of the natural size.

The plate is a half-tone reproduction of Mrs. S. L. Hinde's original sketch made from the larvæ in the natural position, on an island in the Athi River near Kitui, on January 20, 1901. The two larvæ which are figured separately from the group were sketched in order to show the curiously different curves of the waxy filaments in two individuals.



Huber & Sleigh, Limited.

About $\frac{2}{3}$ of the natural size.

H. Hinde.

Protective Resemblance to Flowers of British East African *Flalot*. Kitui, Jan. 23, 1901.



H. Hinde.

André & Sleigh, Limited.

About $\frac{2}{3}$ of the natural size.

Larvæ of British East African *Flata*. Athi River,
Jan. 20, 1901.

Report of the Hope Professor of Zoology, 1900.

The additions in 1900 were numerous and valuable, but not equal in number to those of 1899. The most important is the extensive collection of N. Bornean butterflies made by the late W. B. Pryer, Esq., presented by Mrs. Pryer. Important gifts have also been made by Herbert Druce, Esq., F.L.S. (many localities), R. Shelford, Esq., M.A. (N. Borneo), Guy A. K. Marshall, Esq. (Mashonaland), S. L. Hinde, Esq., and Mrs. Hinde (British East Africa), Professor Poulton (Majorca and Minorca), Mrs. E. C. Bazett (Uganda), Dr. Henry Strachan (Lagos), and R. C. L. Perkins, Esq. (Arizona).

The British Collections have also received numerous important accessions, among which I must specially mention a splendid partial albino female of the High-brown Fritillary (*Argynnis adippe*), captured at Monks Risborough in 1896, and presented by Miss L. B. Evetts.

The final arrangement of the General Collection of butterflies was continued by Mr. Holland, the *Morphinac* (partially finished in 1899) and *Brassolinac* being completed, and a considerable part of the largest family, the *Nymphalinalac* arranged in about 150 drawers. Allowing a margin of cabinet room for Dr. Dixey's arrangement of the *Picrinac*, the part of the collection mentioned above occupied the whole of the consignment of 200 drawers delivered in March 1900. Another consignment of equal size was presented to the Department by Professor Poulton, and delivered in November. Such consignments require six months or more for completion, and therefore the Common University Fund was asked if it could provide the £200 required for a further consignment of 200 drawers, to be delivered about the middle of the present year. The sum was granted, and it is expected that the cabinets will reach Oxford in about a month. A second-hand cabinet was also purchased for the Department at Stevens' sale in July, 1900.

The necessary arrival of fresh cabinets, and the inevitable spreading out of our crowded collection, as the arrangement proceeds, and as gaps are filled by the gifts which are constantly reaching us from all parts of the world, makes it absolutely necessary that more space should be provided. Immediate needs can be met for some years by the use of a small part of the south end of the space now occupied by the Radcliffe Library, and when a new Laboratory is provided for the Wykeham Professor of Physics ample room will be available.

In addition to the above-named work, Mr. Holland arranged the fine collection of *Cicadidae* and *Fulgoridae*, and the consignments of *Phytophaga* (*Coloptera*) which had been submitted to Mr. Jacoby. He also worked through the large collection of butterflies brought by Mr. Richard Evans from Siam, and the duplicates from the British Museum of Natural History.

Mr. Hamilton H. C. J. Druce having very kindly consented to name the Hope Collection of *Lycaenid* butterflies ("Blues" and their allies), a group upon which he is so distinguished an authority, Mr. Holland arranged examples of all the species ready for conveyance to London. The working out of this difficult group will be of inestimable value to the Hope Museum.

A large amount of Mr. Holland's time was also occupied in an examination of the whole of the cabinet drawers and boxes, and placing fresh naphthaline wherever necessary.

Mr. A. H. Hamm has re-set the butterflies of the General Collection as far as the point reached at the close of the year 1900, as well as immense numbers of accessions of all kinds. A large amount of printing, labelling, and cataloguing has also been done, as the concluding pages of this Report will indicate. A large number of specimens illustrating biological problems, such as Mimicry, from Mr. Guy A. K. Marshall (Mashonaland), and Mr. R. Shelford (Sarawak, N. Borneo), have been specially set and labelled by Mr. Hamm for the Bionomic Series. In this condition they have been most successfully photographed as lantern illustrations by Mr. A. Robinson.

The visit of the Council of the Entomological Society took place on June 30 to July 2. Mr. C. O. Waterhouse, Vice-President, Mr. Edward Saunders, F.L.S., Mr. A. Hugh Jones, Mr. H. Donisthorpe, and Mr. C. G. Barrett were present, together with other students of the Insecta not on the Council, viz. Mr. Roland Trimen, F.R.S., Hon. M.A., Mr. M. Jacoby, Mr. Herbert Druce, F.L.S., and many Oxford naturalists. The visitors were entertained by the Hope Curators and their friends. The work of the Hope Museum was much assisted by many kind suggestions.

Mr. Sidgwick and Mr. Pogson Smith have continued the arrangement of the British *Tineina*. Mr. C. G. Barrett kindly assisted in this work on the occasion of his visit. Mr. Gilbert J. Arrow and Mr. C. J. Gahan have worked through groups of our Coleoptera, which they have been studying in the Natural History Museum, and Mr. W. L. Distant has similarly identified the Westwood types in our General Collection of certain sections of the Hemiptera. He has published the results in two papers in the "Proceedings of the Zoological Society," copies of which will appear in the Hope Reports.

Mr. Jacoby has continued his kind assistance with the Phytophaga, a labour which will now soon be completed.

Dr. Dixey has continued the arrangement of the *Picrinæ* in the new cabinets, and has carried the preliminary work a long way ahead of the space at his disposal. On Feb. 28, 1900, he was elected a Hope Curator, in place of Mr. Edward Chapman who had left Oxford. It is very pleasant to welcome Dr. Dixey upon the governing body of the Hope Collections, which he has done so much to render efficient. He has, indeed, made his own special group, the *Picrinæ*, a model to all Museums.

During the year Mr. W. J. Lucas has visited the Department, and has helped us greatly in his own group, the British Odonata. Mr. Percy H. Grimshaw has come to inspect the General Collection of Diptera. Dr. P. L. Sclater, F.R.S., Professor A. S. Packard, Professor W. T. Sedgwick, and Professor J. W. Gregory have also visited the Hope Museum.

Before concluding I desire as in previous years to express my indebtedness to the members of the staff of the Insect Department, of the British Museum of Natural History, as well as my satisfaction that the Hope Collection should have afforded them assistance in their work.

As regards research during the year 1900, I have already referred to the work upon bionomic questions carried on upon the collections of Mr. Guy A. K. Marshall, and Mr. R. Shelford. A condensed account of the chief results was presented to section D of the British Association at Bradford by Professor Poulton.

Mr. N. Annandale continued and completed his paper on his observations in Siam.

Mr. Malcolm Burr published a paper on the British Orthoptera in the Hope Museum in the "Entomologists' Record" for April, 1900.

The important paper on Mr. C. V. A. Peel's Somaliland captures appeared in the "Proc. Zool. Soc." for the year 1900 (p. 2).

Volume II of the Hope Reports was not issued until the beginning of the present year (1901).

ADDITIONS TO THE COLLECTION IN 1896.

Five butterflies from Cannanore on the Malabar Coast (1896), part of a large consignment presented by A. G. Cardew, Esq., M.A., Queen's College, which had been put aside as duplicates, have now been catalogued for the General Collection.

ADDITIONS TO THE COLLECTION IN 1897.

Since the last Report the valuable collections made in Somaliland in 1895 and 1897, by C. V. A. Peel, Esq., and presented in 1897, have been catalogued and incorporated. The delay in publishing the paper describing the collection was the cause of the work being postponed to so late a date,

inasmuch as it is desirable to refer to the publication on the printed labels. This valuable and very varied collection of 523 Insecta, Myriapoda, and Arachnida contains the types or co-types of several new species (Rhopalocera, Heterocera, Coleoptera, Diptera, Orthoptera and Arachnida) described by distinguished specialists in the various groups in the "Proc. Zool. Soc." for 1900. Mr. Peel is greatly to be congratulated on the numerous additions to knowledge which have resulted from his two journeys to Somaliland.

ADDITIONS TO THE COLLECTION IN 1898.

A useful set of insects of many Orders, captured in the "winter" season at Sao Paulo, S. Brazil, presented in 1898, by Malcolm Burr, Esq., New College, has been catalogued and incorporated since the appearance of the last Report.

The gifts of Herbert Druce, Esq., F.L.S., and of F. A. Dixey, Esq., D.M., Wadham College, still remain uncatalogued, the former in order that the work may be done in association with the generous later gifts, the later in the hope that further information may be forthcoming.

ADDITIONS TO THE COLLECTION IN 1899.

In the Report of last year nearly 7000 specimens, received in 1899, were recorded as catalogued and incorporated. Great progress has been made since then, and the following accessions are now gratefully acknowledged.

Eighty-four butterflies and one moth from various localities in the Bernese Oberland (1898) were presented by Hugh Richardson, Esq. The data accompanying the specimens are excellent.

A set of 120 butterflies and one moth from Banff, Alberta, Canada, and one butterfly from Rush Lake, Ass., Canada (1898), were presented by H. J. Elwes, Esq., F.R.S. The data accompanying the specimens are admirable.

A set of 339 insects of various Orders, chiefly butterflies,

from Ceylon (1899), was presented by E. S. Goodrich, Esq., M.A., Merton College. The data are excellent and render the collection of great value to the Hope Museum. Many specimens showing injuries probably caused by enemies will be added to the Bionomic Series.

Eighty-two insects of various Orders, chiefly butterflies, from Fiji, and 4 from Vancouver City, B. C., Canada, were presented by Professor Gustave Gilson of Louvain University. The specimens are of great value to the Hope Collection on account of the locality. A pair of convergent *Euplocina* will be a welcome addition to the Bionomic Series.

Collections of 125 Lepidoptera, chiefly butterflies from various localities in Norway (1898), 20 from Eastern Carinthia (1897), and 56 from various localities in Switzerland (1899), were presented by Dr. T. A. Chapman. Many of the specimens are very welcome additions, especially a set of *Ercbia flavofasciata* from Campolungo, Fusio; but all are useful on account of the data.

The following numerous and valuable accessions are due to the generosity of G. C. Griffiths, Esq.:

Fifty butterflies and one moth from Chandolin, Switzerland (1899). These specimens, collected by Professor C. Blachier, are in beautiful condition.

Eighty-six insects, chiefly butterflies, from Zomba; 15 Lepidoptera from Sumatra; 9 fine Papilios from the Moluccas; 2 fine *Lycaenidae*, new to the Hope Collection, from Kapaur, New Guinea; 13 Lepidoptera from various localities in Queensland (1897-99); 18 butterflies from the Bombay Presidency (1898); a moth from Perak; a Pierid butterfly from Tanganyika; 2 Syntomid Moths from the Tugela River; 29 Hymenoptera, Neuroptera and Orthoptera from Japan.

Probably the most important addition to the Hope Collection of moths, since Mrs. F. W. Hope's gift of the W. W. Saunders' Heterocera, is due to the generosity of Roland Trimen, Esq., Hon. M.A., F.R.S., who presented the collection made by Cecil N. Barker, Esq., in Natal, chiefly in the neighbourhood of Durban (1887-96). The specimens, of

which there are 884, belonging to between four and five hundred species, are in beautiful condition and have stood the ordeal of re-setting remarkably well.

A Neuropteran (*Ascalaphus*) from Natal, and 4 specimens of *Melanargia occitanica*, from Hyères (1899), in fine condition, were also presented by Roland Trimen, Esq.

Colonel J. W. Yerbury presented a valuable collection of Diptera captured by him in the neighbourhood of Aden (1895), including 84 *Syrphidae* described by G. H. Verrall, Esq., F.E.S., with the type of *Helophilus africanus*, and 93 *Asilidae* described by F. M. van der Wulp, with the types of 15 new species. Accompanying the collection are Colonel Yerbury's valuable MS. notes on the habits, modes of occurrence, &c., of the species. The data on the specimens are remarkably precise. A few of the specimens are placed in the Bionomic Series, viz., *Eristalis crassipes* and a bee which it resembles found on the same flowers, and two asilid flies captured in the act of devouring butterflies.

Colonel Yerbury also presented *Oestrus ovis* from Simla (1898), and 3 imagos and 4 puparia of *Cephalomyia maculata*, the gad-fly of the camel, an insect of great interest and rarity, bred by him from larvae obtained in the neighbourhood of Aden in 1895.

A specimen of *Argynnis lathonia* from the neighbourhood of Carnac, Brittany, was presented by Professor Poulton.

Ten specimens of a local Pierid butterfly (*Neophasia menapia*) from Vancouver Island (1896), were presented by Mr. A. H. Hamm.

In addition to the invaluable material from Mashonaland presented by Guy A. K. Marshall, Esq., and described in the Report of last year, a later generous consignment, captured or bred in 1899, contained the following specimens, many of which are of the highest interest for the study of Mimicry, seasonal changes in appearance, &c.

Eighty-two butterflies, captured by Mr. Marshall in the neighbourhood of Salisbury (1899), containing the very rare Lycaenid, *Mimacraea marshalli*, new to the Hope Collection, and a very fine set of *Teracoli* captured at various dates.

Two specimens of *Mimacrata marshalli*, and two specimens of its model, *Limnas chrysippus*, taken on the same day (April 9); for the Mimicry Series.

Twenty-four butterflies, with wings notched, probably as a result of the attacks of enemies.

A series of 14 bred specimens of *Precis sesamus* (one being the *octavia* form), subjected to various conditions of moisture and heat during the pupal period. Precise and accurate data accompany the specimens, which constitute a solid mass of evidence on which to build lasting conclusions as to the manner in which this, the most wonderful seasonal change hitherto recorded, is brought about.

Five bred specimens of *Precis archesia* (3) and *P. pelasgis* (2), two other deeply interesting seasonal forms allied to the above. One of the specimens of *P. archesia* had been subjected to moist heat in the pupal stage. The dates of all the stages are recorded in the case of the two specimens of *P. pelasgis*.

Three female specimens of *Teracolus achine*, and the 7 offspring reared from their eggs, some under normal conditions, others in moist heat; four females of *Teracolus omphale* and their 14 offspring similarly treated. Most accurate data are given, and in this case also enable firm conclusions to be reached upon the much discussed seasonal changes of the *Teracoli*.

Professor R. Meldola, F.R.S., presented 225 insects of various Orders, chiefly Lepidoptera, and Mrs. Meldola 3 moths, from Switzerland (1899). Professor Meldola also presented 19 Lepidoptera from Cape Gris Nez. The data accompanying all these specimens are extremely full and precise.

Twelve fine Coleoptera (*Dynastidae* and *Lucanidae*) from Darjiling, were presented by Henry Ward, Esq.

Fifty-one butterflies and one moth were presented by Mark L. Sykes, Esq., including a very useful set of specimens from the Gabun River, and valuable specimens from a variety of localities, many of which are specially wanted for the Mimicry Series, others for the General Collection.

An *Argynnis* from Tonset, Norway (1899), was presented by E. N. Bennett, Esq., M.A., Hertford College.

A flower-like spider from Sylhet (1899) was presented by W. H. Jackson, Esq., M.A., Keble College.

Acraca serena, female, from Zanzibar (1899), was presented by Mrs. E. C. Bazett.

A large number of specimens are still uncatalogued, including those to be selected from the Collection of the East India Company, and the great majority of the duplicates from the British Museum of Natural History; the majority of the generous gifts of Herbert Druce, Esq., F.L.S.; the Siamese captures of Richard Evans, Esq., M.A., B.Sc., Jesus College; the great majority of the consignments presented by R. Shelford, Esq., M.A., from Sarawak; the butterflies presented by Abbot H. Thayer, Esq., and by D. Chaplin, Esq.; the Lepidoptera by Osbert H. Howarth, Esq., and by Ronald W. Poulton.

BRITISH COLLECTIONS, 1899.

Fifty-six Coleoptera from various British localities were presented by H. Donisthorpe, Esq. The data accompanying the specimens are very full and precise, rendering them a most valuable accession.

Fifty-three Hymenoptera Aculeata from various British localities were presented by Edward Saunders, Esq., F.L.S. The species were specially selected to fill gaps in our very complete collection of British Aculeates, and are correspondingly valuable.

A fine series of 12 *Caradrina ambigua* from Boscombe (1899) was presented by Major R. B. Robertson.

Three cocoons of the rare "Hook-tip" (*Drepana Sicula*), spun by larvae found in the Leigh Woods, Clifton, Bristol (1898), were presented by G. C. Griffiths, Esq.

Eleven Hymenoptera Aculeata and mimetic Diptera from various localities in Scotland (1898) were presented by Colonel J. W. Yerbury.

Twenty-three insects of various Orders, chiefly Hymeno-

ptera, from Charney, near Wantage, and from Oxford (1899), were presented by Mr. H. Trim.

Eighteen insects of various Orders from the neighbourhood of Oxford (1899) were presented by Mr. W. Holland. Mr. Holland also presented a most interesting series of 12 specimens of the beetle *Cleonus sulcirostris*, 4 from the reddish sand of Boar's Hill (1899), 4 from sandy soil on Shotover Hill (1894), 4 from the pale coast sand of Deal (1896). Each group shows a marked resemblance to the soil on which it was found, that from Boar's Hill being especially distinct from the other two. The observation, the first of its kind in the Coleoptera, has been described in "Transactions of the Entomological Society," London, 1899, p. 430. The specimens are a welcome addition to the Bionomic Series.

A hornet (worker) from Summertown (1899) was presented by the captor, Mr. G. Webb. Curiously enough, the Hope Museum did not contain a single specimen labelled as captured in the Oxford district.

A male hornet from Birdlip (1899) was presented by Mrs. A. G. Butler.

Three Coleoptera were presented by Miss Ruth Butler, and an imago and pupa-case of *Macroglossa stellatarum* by Miss C. V. Butler. All were obtained at Birdlip (1899).

A set of 101 insects of various Orders from the neighbourhood of Oxford; Lingfield, S.E. Surrey; and St. Helen's, Isle of Wight (1899), was presented by Professor Poulton. The series includes a group of Hymenoptera and mimetic Diptera, for the Bionomic Series.

A beetle was presented by Janet Poulton, and a moth by Ronald W. Poulton, both from Oxford (1899).

A local moth (*Pyralis costalis*) from Caversham (1899) was presented by Miss Cora B. Sanders.

A hundred and sixteen insects of various Orders from Oxford; Fleet, Hampshire; and S. Devon (1899), were presented by Mr. A. H. Hamm. Six of these British Lepidoptera will be added to the General Collection.

The following insects from Oxford (1899) were presented by the captors:

A dragon-fly by Miss Wright ; a dragon-fly (*Gomphus*), and a specimen of *Eristalis florens* and its puparium, by Mr. A. Drew ; 2 moths by Mr. A. Robinson ; a pair of *Sphinx ligustri*, found on the same rose-bush, by Mrs. E. H. Hayes ; a specimen of *Smerinthus populi* by Mr. H. Higgs ; 4 specimens (3 green and 1 red) of *Cassida muræa* bred from larvae found on *Inula dysenterica* near S. Hinksey, by J. J. Walker, Esq., R.N. ; *Sphinx ligustri* and its pupa-case, by Mr. J. T. Long ; a pair of *Smerinthus ocellatus*, and a specimen of *Cerura vinula* and its cocoon, by P. J. Bayzand, Esq.

A specimen of *Sphinx ligustri* from Wotton, Herts (1899), was presented by Mr. A. Overington.

The only British specimens, received in 1899, still uncatalogued are the moths from N. Cornwall, presented by A. G. Cardew, Esq., M.A., Queen's College.

ADDITIONS TO THE COLLECTION IN 1900.

Large additions were made during the last year, although not equal in amount to those of 1899. Fair progress has been made with the labelling, cataloguing, and incorporating, but a large majority are still unfinished and can only be provisionally acknowledged in the present Report.

A valuable series of 310 butterflies and 1 moth collected in April, 1897, in Southern Arizona, and 5 butterflies from the neighbourhood of New Orleans, were presented by R. C. L. Perkins, Esq. All the species were greatly wanted for the accurate data accompanying them, while many were new to the Hope Collection.

Very large and valuable accessions are due to the kindness of R. Shelford, Esq., M.A. (Cantab.), the Curator of the Sarawak Museum (Brit. N. Borneo). Only a part have been labelled and catalogued, including 16 butterflies from Sarawak, 2 from the N. Shan States, 4 from Malacca, and 1 from Flores Straits, and 58 insects of various Orders from Mt. Matang (Sarawak), including some interesting specimens for the Bionomic Series. The insects were collected at various dates.

One butterfly and 7 moths from various localities were presented by the Zoological Museum, Tring, Hertfordshire.

A beautiful group of 4 similar butterflies belonging to three Sub-Families from New Britain (1899) was presented by Col. C. Swinhoe, Hon. M.A., constituting a valuable addition to that part of the Bionomic Series which illustrates theories of Mimicry. Col. Swinhoe also presented 4 butterflies of the genus *Acraca* from S. and S.E. Africa (1899).

A very interesting pair of insects was presented to the Bionomic Series by H. Donisthorpe, Esq., viz. the ~~Hemipteron~~ *Staphylin* *Lomechusa strumosa* and its host *Formica* ~~rufa~~ *sanguinea*, both captured in the neighbourhood of Roermond, Holland, by Father Wasmann in 1897.

A fine series of 93 butterflies from British East Africa (Mombasa, Machakos, and Machakos Road), 1900, was presented by the captors, S. L. Hinde, Esq., and Mrs. Hinde. The series included several interesting examples of seasonal forms, including a most beautiful variety intermediate between *Precis octavia* (wet season) and *P. sesamus* (dry), of forms showing the influence of local conditions, such as height above the sea and dryness. There were also valuable groups of the different varieties of the same species captured in less than an hour on a patch of ground a few yards in extent. The excellent condition of the specimens and the admirable data accompanying them render the gift especially valuable to the Hope Museum.

Later in the year another valuable series of 113 specimens from Machakos (June 6, 1900) and Kitui (Nov. and Dec.) was presented by the same generous donors. The series included a very interesting set of 68 Lepidoptera, almost exclusively butterflies, caught in two hours at a single spot at Kitui, on Dec. 11. The group represents in a most interesting manner a characteristic assemblage of Rhopalocera in this locality. It contains several seasonal forms (wet) of butterflies of the genus *Precis* and some interesting local varieties. There are also species which are new to our collection, and others which are almost wanting. Among the former one beautiful *Acraca*, also absent from the British Museum, is conspicuous.

A comparison between the Machakos and Kitui seasonal forms of the same species is of great interest.

A fine series of two forms of a Pierine butterfly, *Catopsilia crocale* (8) and *C. catilla* (6), and a pair of another species (*C. pyranthe*), all captured flying together on August 11, 1900, in the Kangra Valley, W. Himalayas, were presented by L. de Nicéville, Esq. A pair of the former varieties, captured *in copula*, in the same locality (August 13), was also presented by the same donor. The specimens are of the highest interest, showing that, in this locality, two forms which have been described as seasonal, and may be seasonal in other parts of their range, do undoubtedly occur together.

Twenty-four butterflies (1900) from near Eshowe, Zululand, and one from Natal, were presented by C. B. Russell, Esq., M.A., Balliol College. They include a Lycænid, showing injuries to the wings, probably caused by the attacks of an enemy (for the Bionomic Series).

A *Blatta* from Maitland Camp, near Cape Town (1900), was presented by Trooper H. E. Nash.

Twenty-one insects of various Orders, from Topeka, Kansas, U. S. A. (1900), were presented by C. L. Pribble, Esq. They include specimens showing the effects of probable attacks of enemies, and the Danaine butterfly, *Anosia plexippus*, with its Nymphaline mimic, captured on the same day (for the Bionomic Series).

A rare Hesperid butterfly (*Baoris netopha*) from Salisbury, Mashonaland (1900), was presented by Guy A. K. Marshall, Esq.

Twenty-four butterflies from German New Guinea (about 1897), including a *Euploea* and an Elymnine mimic, for the Bionomic Series, were presented by Mr. A. H. Hamm.

Eight *Cetoniidae* (Coleoptera), from various localities, were received in exchange from O. E. Janson, Esq.

Fifty insects of various Orders, and a spider's egg-cocoon from Epe, the Mainland, Lagos, West Africa (1900), were presented by Dr. A. J. Brodie. Although much injured in the journey, many of the specimens are very welcome to the Hope Department.

Five specimens of the wide-spread butterfly, *Hypolimnas*

misippus, collected in the Mid-Atlantic in 1893 by Captain E. P. Ellis, were presented by J. W. Tutt, Esq.

Thirteen Arthropoda of many kinds, chiefly Arachnida, found alive (December, 1900) in the Oxford Museum, with specimens from Yezo, Japan, were presented by H. Balfour, Esq., M.A., Trinity College.

Thirty-one Lepidoptera, captured in Alberta, Canada (1900), were presented by H. J. Elwes, Esq., F.R.S.

A valuable set of 184 insects, almost exclusively Lepidoptera, was presented by Mrs. E. C. Bazett. They were captured by Mrs. Leakey in 1900, at or near Mengo (chiefly at Ndeje), Uganda, and include many valuable accessions, especially a number of moths in fine condition, and the very rare Danaine butterfly, *Melinda mercedonia*, new to our collection. The locality renders all the specimens most welcome.

A collection of 94 butterflies from Socotra (1898-9) and one from the neighbourhood of Aden (1898) were presented by the captor, W. R. Ogilvie Grant, Esq. The data are very precise, and the specimens form a valuable accession.

Thirty-one butterflies from the neighbourhood of Freetown, Sierra Leone (1895-6), were presented by Major W. G. Clements.

Eleven butterflies from Sierra Leone (1897-8) were presented by F. W. J. Jackson, Esq.

Twenty-nine butterflies, collected in various localities in Nyassaland (1899) by E. M. de Jersey, Esq., were presented by the British Museum of Natural History, together with 33 butterflies collected in various parts of the colony of Lagos (1898) by Dr. Henry Strachan.

Dr. Henry Strachan presented a collection of 212 insects of many Orders and 3 Arachnida from Lagos, chiefly the Ogun River basin (1899-1900). Many specimens are very welcome on account of their rarity, and all on account of the locality.

The following specimens were purchased of J. C. Stevens: Sixty-eight butterflies from Tenerife (1890). Fifty-two butterflies and 2 moths from the Andaman Islands. Forty-eight Lepidoptera from Queensland. Seventy Lepidoptera and

1 Homopteron from Jamaica (1898). Seventeen Lepidoptera and 1 Neuropteron from China (almost exclusively from the West). Fifteen Lepidoptera from Japan, and 15 from Columbia. Twelve Lepidoptera from Honduras, 8 from Venezuela, 2 from Colorado, 1 from Paraguay, 7 from Perak, Malacca, 3 from the Moluccas, 8 from Borneo, 1 from New Britain, 4 from Kashmir, 3 without locality.

A set of Lepidoptera, almost exclusively picked specimens for the Mimicry Series, purchased of Watkins and Doncaster, are as yet uncatalogued.

A fine collection of Orthoptera, including many types, was purchased from Signor M. A. de Bormans. Many specimens were unfortunately much injured in the carriage.

The following gifts are as yet uncatalogued :

One of the most important accessions of recent years is the fine collection of butterflies made in British North Borneo, chiefly from the East Coast Residency from 1878 to 1898, by the late W. B. Pryer, Esq.; presented by Mrs. W. B. Pryer. Many moths are also included in the collection. The insects will require a considerable amount of attention inasmuch as the tropical heat had warped many of the boxes and let in the dust and mould. The whole collection also requires re-setting, a labour which is now being undertaken. The labels are already printed. When completed and incorporated the Hope Collections will be enriched by many hundreds of specimens by this generous gift.

Next in importance is the collection of insects made in Majorca and Minorca (April, 1900), and to a small extent in Barcelona (March, 1900), by Professor Poulton, including captures by Mrs. Poulton and by E. S. Goodrich, Esq., M.A., Merton College. The collection consists of hundreds of specimens of many Orders. All have been set and labelled, so that nearly all the necessary mechanical labour has been expended on them. The Hymenoptera Aculeata have been worked out by Edward Saunders, Esq., F.L.S., the Diptera by Colonel Yerbury. The former include some interesting varieties and one fine new species of *Nomada*, of which 4 specimens were obtained.

A valuable series of Coleoptera and other insects from the neighbourhood of Mahon, Minorca, was presented by Señ. Mauricio Hernandez.

A very fine and valuable collection of Orthoptera, chiefly *Acridiidae*, from Salisbury, Mashonaland (1900), has been presented by Guy A. K. Marshall, Esq. The insects are now in the hands of Mr. Malcolm Burr, New College, who is working them out. Mr. Marshall also presented some extremely fine examples of mimetic insects of various Orders from the same locality, together with large numbers of the Hymenoptera which form the models most commonly resembled. A very useful collection of Hymenoptera and their mimics from the same locality was also presented by R. H. Thomas, Esq. The postal service was probably much deranged by the War, and these consignments were more badly treated than any I have previously received from Salisbury.

Extremely fine consignments of insects of many Orders from Sarawak, British North Borneo, have been presented by R. Shelford, Esq., M.A., the Curator of the Sarawak Museum.

The collection of moths has been greatly enriched, as in previous years, by the generosity of Herbert Druce, Esq., F.L.S., who has also presented a number of butterflies and insects of other Orders from many localities.

Collections of Lepidoptera from Queensland, of butterflies from Sarawak, from the Khasia Hills, and from Tobago, and of moths from Mexico, were presented by G. C. Griffiths, Esq., who has given so many valuable donations to the Hope Museum.

A valuable collection of Lepidoptera from Trinidad was presented by Prof. R. Meldola, F.R.S.

A small collection of insects from Iceland and the Faröe Islands was presented by N. Annandale, Esq., B.A., Balliol College.

Two Lycaenid butterflies from Egypt were presented by Prof. Wyndham R. Dunstan, F.R.S., and a moth from Paris by Prof. Poulton.

Lepidoptera and Coleoptera from Port Elizabeth, and many

fine species of Orthoptera from Montenegro and other localities, were presented by Malcolm Burr, Esq., New College.

A fine collection of dragon-flies from Java was presented by R. McLachlan, Esq., F.R.S.

A few Oriental butterflies from Col. Swinhoe's collection were presented by Mr. W. Holland.

Moths from Sarawak were presented by Col. Swinhoe, Hon. M.A., Wadham College.

Insects of many Orders from S. Africa were presented by E. N. Bennett, Esq., M.A., Hertford College.

Lepidoptera from the Fionnay Valley, Switzerland, were presented by H. M. Wallis, Esq., and A. Wallis, Esq.

Butterflies bred from European larvae were presented by F. Merrifield, Esq.

Coleoptera from the United States were presented by Ralph d'A. Morrell, Esq., and from the Oriental Region by F. W. Andrewes, Esq., D.M., Christ Church, and H. E. Andrewes, Esq.

In addition to the above-mentioned gifts, a very large number of duplicate butterflies were generously presented by the British Museum of Natural History. These will fill many gaps in our series and supply innumerable examples from localities which are unrepresented in the Oxford collection.

The British Collections have also been much enriched although a large proportion of the accessions are not yet catalogued and incorporated.

A valuable series of 186 Coleoptera and 36 Rhynchota (both Hemiptera and Homoptera) from various British localities, all very carefully recorded and dated, were presented by H. Donisthorpe, Esq.

A pair of *Prosopis palustris*, a bee new to science, from Wicken Fen, Cambridge (1899), was presented by the captor, R. C. L. Perkins, Esq., B.A.

A co-type of *Eriocrania fimbriata*, a moth new to science, from Wellington College (1894), was presented by the captor, Mr. A. H. Hamm.

Six specimens of the rare moth *Eupoecilia degreyana*, from Thetford (1900), were presented by Lord Walsingham.

A magnificent variety of *Argynnis adippe* (the High-brown Fritillary) was presented by the captor, Miss L. B. Evetts. In this specimen, a female, the whole of the amber brown ground colour is replaced by white, the black markings remaining unchanged. Partial albinos of this kind are known to occur, although very rarely, in other species of the genus, but this is I believe the first recorded example in *A. adippe*. The specimen has the additional interest that it was captured in the neighbourhood of Oxford, on the eastern slope of White Leaf Hill, Monks Risborough, in July, 1896.

A pair of *Colias hyale*, captured in 1900 at Tackley, near Bletchington, was also presented by Miss Evetts.

The following insects, &c., from Oxford (1900), were presented by the captors:—*Cerura vinula*, by Mr. G. Long; *Smicrinthus ocellatus*, by Mr. C. Bolton; 2 Lepidoptera and a *Vespa*, by Mr. H. Trim; an ichneumon, by Mr. A. Robinson; *Zeuzera aesculi*, by Mr. F. C. Hall; a Coleopteron, by Mr. T. H. Walker; a spider, by Miss Acland.

Four dragon flies from Newton Abbot, South Devon (1900), were presented by A. E. Holdaway, Esq.

A very useful set of 47 insects, of many Orders, from Surrey (including the rare dragon-fly *S. flavicolum*, the local *S. sanguineum*, and *A. imperator*, which is only captured with great difficulty), Hampshire (New Forest), and the Oxford district (11 specimens), was presented by W. J. Lucas, Esq.

Four cast nymph skins of *Aeschna cyanea* from South Leigh (1900) were presented by the Rev. Arthur East.

The following accessions to the British Collections have not yet been catalogued:

Diptera from Scotch and English localities, and Hymenoptera from the former, including many specimens for the Bionomic Series, illustrating mimicry, presented by Colonel J. W. Verbury.

The year 1900 was remarkable for the abundance of the larvae and perfect moths of the "Death's Head" (*Acherontia atropos*), and the Hope Department received larvae from Mr. Austin, Mr. W. H. Greenaway, Mr. F. Lewis, Mr. R. Jones, and Miss Churchill, two pupae from Mr. N. Brett, and a perfect insect from Mr. G. Hunt.

British insects were also presented by the following, and will be described in detail in the next Report when they are catalogued:—Rev. J. W. B. Bell, M.A., W. H. Jackson, Esq., D.Sc., Keble College, R. W. Poulton, E. P. Poulton, Eustace Palmer, Esq., Miss C. B. Sanders, H. E. Butler, Esq., Miss Brown, G. C. Griffiths, Esq., F. A. Dixey, Esq., D.M., Wadham College, Giles Dixey, Mrs. Gotch, Edward Saunders, Esq., F.L.S., H. Donisthorpe, Esq., Professor Poulton, Mr. W. Holland and Mr. A. H. Hamm, H. St. G. Gray, Esq., H. A. Ormerod, Esq., Dr. Stark, W. G. Pogson Smith, Esq., M.A.

Some of the above-named donors presented large numbers of insects. When all are catalogued it will be seen that the additions to the British Collections in 1900 were very extensive.

A large series of *Hepialus humuli* from the Shetland Islands was purchased at Stevens's sale.

ADDITIONS TO THE HOPE LIBRARY IN 1900.

The Trustees of the British Museum presented the "Catalogue of the Lepidoptera Phalaenae," vol. ii, by Sir George F. Hampson, and also papers sent out to collectors of insects.

The Smithsonian Institution (United States National Museum, Washington) presented the publications which deal with the subjects of the Department, including the Annual Reports for 1898 and 1899, and valuable monographs by A. Busck, Esq., Dr. John B. Smith, Sc.D., Dr. Harrison G. Dyar, Ph.D., William H. Ashmead, Esq., D.W. Coquillett, Esq., and Miss Mary J. Rathbun.

The University of the State of New York presented a fine set of Reports of the State Museum (49. 3, 50. 2, 51. 1, 51. 2) and the College Department (2. 1 and 2. 2).

The Radcliffe Librarian, Oxford, presented the Catalogue of Books added during 1899.

The Delegates of the Clarendon Press presented Part II of the "Catalogue of Eastern and Australian Lepidoptera Heterocera in the Collection of the Oxford University

Museum," by Col. Swinhoe (Pterophoridae and Tineina by Lord Walsingham and J. Hartley Durrant), Oxford, 1900.

The Boston Society of Natural History and the Bombay Natural History Society presented their publications for the year 1900.

The Transactions of the Entomological Society, and the Transactions and Journal of the Linnean Society for the year 1900, were presented by Professor Poulton; also a list of Lepidoptera of Folkestone, 1870.

The Superintendent of the Museum of Zoology, Cambridge, presented the Report of the Syndicate for 1899.

"Fauna Hawaiensis," vol. ii, Part II (Coleoptera), and vol. ii, Part IV (Entozoa), were presented by the respective authors, R. C. L. Perkins, Esq., B.A., Jesus College, and A. E. Shipley, Esq., M.A., Christ's College, Cambridge.

The Liverpool School of Tropical Medicine presented Memoir I, "Instructions for the prevention of Malarial Fever"; and Major Ronald Ross, D.P.H., M.R.C.S., presented "Malaria and Mosquitoes," and Memoir II, "Report of the Malaria Expedition" (1900).

Copies of original papers on the Arthropoda have been presented by the following authors:—M. Henri de Saussure (2 memoirs); Dr. A. G. Butler (3 papers); W. L. Distant, Esq. (9 papers); W. F. Kirby (5 papers); Horace St. J. Donisthorpe, Esq., F.E.S. (3 papers); G. W. Kirkaldy, Esq., F.E.S. (14 papers); O. A. Sayce, Esq. (2 papers); Samuel H. Scudder, Esq. (3 papers, including an important "Catalogue of the Described Orthoptera of the United States and Canada," 1900); Sir G. F. Hampson, B.A., F.Z.S., &c. ("The Moths of South Africa," Part I); Rev. T. R. R. Stebbing, F.R.S. ("Crustacea from the Falkland Islands"); F. A. Dixey, Esq., D.M., Wadham College; G. C. Bignell, Esq., F.E.S.; F. V. Theobald, Esq., M.A.; Gilbert J. Arrow, Esq., F.E.S.; Malcolm Burr, Esq., F.E.S., New College (2 papers, including a monograph on the *Eumastacides*); George H. Carpenter, Esq., B.Sc.; W. P. Hay, Esq., M.S.; Martin Jacoby, Esq., F.E.S. (Phytophagous Coleoptera from S. and Central Africa); M. André Sémenow; Professor Roland Thaxter, Harvard

University ; Ernest W. L. Holt, Esq., and W. J. Beaumont, Esq., B.A., Cantab. ; M. W. D. Lepeschkin (a Monograph on the Copepoda).

“Illustrations of the Zoology of the Royal Indian Marine Survey Ship ‘Investigator’” (Fishes Part VII, Crustacea Part VIII, and Index Part I, 1892-1900) was presented by the Superintendent of the Indian Museum, Calcutta.

A valuable Catalogue of the Coleoptera of Minorca, by Dr. D. Francisco Cardona y Orfila Pbro (Mahon, 1872), as well as a supplementary list of Coleoptera by the same author (Mahon, 1878), and a supplementary list of the Balearic Fauna by Dr. Juan J. Rodriguez (1887), were presented by Señ. Mauricio Hernandez of Mahon, Minorca.

Several books were purchased, including “The Butterfly Book,” by W. J. Holland (New York, 1899), and among second-hand works a fine copy of W. Lewin’s “Insects of Great Britain” (London, 1795). A fine series of monographs on Orthoptera by Fischer, de Saussure, Brünner von Wattenwyl, and Bolivar was purchased from Sign. M. A. de Bormans.

The parts of Barrett’s “British Lepidoptera,” the Ray Society volume, and the parts of Rippon’s “Icones Ornithopterorum” for the year were also purchased.

“Die Physiologie der facettirten Augen,” by Professor S. Exner of Vienna, purchased in 1898, should have been included in the Report of that year.

In addition to the gifts acknowledged above, a few works presented in 1899 were accidentally omitted from the Report of last year. I have pleasure in thanking Dr. John B. Smith ; Vernon L. Kellogg, Esq., M.S. ; W. P. Hay, Esq., M.S. ; and Miss Harriet Richardson for presenting copies of their papers, published through the Smithsonian Institution, Washington ; Col. J. W. Yerbury for presenting copies of the papers of Dr. F. M. van der Wulp, on the *Asilidae*, and G. H. Verrall, Esq., F.E.S., on the *Syrphidae*, collected near Aden ; Miss Edith M. Pratt, B.Sc., and Professor Sydney J. Hickson, F.R.S. ; and Dr. G. S. Brady, F.R.S., for presenting copies of their papers.

A valuable set of 15 papers, chiefly upon the *Rhynchota*, was presented by the author, W. L. Distant, Esq.

The Third Supplementary List of the Natural History of Hastings and St. Leonards, presented by the author, the Rev. E. N. Bloomfield, was also unfortunately omitted from the Report.

Two papers "On the method of Organic Evolution," presented by the author, Dr. Alfred R. Wallace, in 1895, were unfortunately not acknowledged in the Report of that year.

EDWARD B. POULTON.

Report of the Hope Professor of Zoology, 1901.

The additions to the Collection in 1901 were not so numerous as in 1900. Nearly 6,400 specimens received in the latter year have now been catalogued and incorporated, and large numbers still remain to be included. The most important of these is the very fine consignment from Sarawak, Borneo, presented by R. Shelford, Esq., M.A., Curator of the Sarawak Museum.

About 2,000 specimens presented in 1901 have been incorporated, and are acknowledged in detail in the later part of this Report. When the whole of the 1901 accessions are included, the numbers will probably not exceed 4,000 altogether. The most important and valuable of the gifts already catalogued are the following.

The Rhodesian insects collected and forming the material of important experiments by Guy A. K. Marshall, Esq., are of inestimable value to the Department. The specimens have in large part been specially collected and specially observed to afford evidence bearing on various biological problems of the highest interest and importance. Some of these experiments have been described by Mr. Marshall (*Ann. and Mag. Nat. Hist.* 1901, vol. ii. p. 398); Dr. F. A. Dixey has discussed nearly the whole of Mr. Marshall's material bearing on seasonal dimorphism in butterflies and its causes, and has compared it with a large amount of other material from other parts of the world, in the *Hope Department* (*Trans. Ent. Soc. Lond.*, 1902, p. 189); while the remainder of Mr. Marshall's specimens and an immense mass of observations recorded by him have been communicated to the Entomological Society of London, and will appear later in the year. This last paper describes the whole of the South African material bearing on mimicry, warning colours, the struggle for existence in insects, &c., accumulated by a matchless observer during the five years ending with the close of 1901. Owing to the generosity of Mr. Guy Marshall, the whole of this invaluable

evidence on these much-disputed questions can be studied in the Hope Department.

Of special value to the University Collections are also the donations by C. J. M. Gordon, Esq., M.A., Balliol College, from Southern Nigeria; by Col. J. W. Yerbury, from South Europe; by F. W. Mark, Esq., H.M. Consul, Santos, Brazil, from Bogota, Columbia; by Miss Mary G. Holmes, from Manitoba; by W. L. S. Loat, Esq., from the White Nile; by S. L. Hinde, Esq., and Mrs. Hinde, from British East Africa; by the Trustees of the British Museum of Natural History, from Burmah.

The British Collections have been specially enriched by a perfect specimen of *Vanessa antiopa* ("The Camberwell Beauty"), captured (Aug. 19, 1900) and presented by Rev. J. W. B. Bell, M.A., at Pyrton, Oxon; by Hymenoptera and mimetic Diptera from various British and Irish localities, by Col. J. W. Yerbury; by Lepidoptera from many English localities, by F. A. Dixey, Esq., D.M., Wadham College; by Lepidoptera from Perthshire, by G. C. Griffiths, Esq.

The welcome gift of nearly 400 beautifully set British flies from the neighbourhood of Lyndhurst in the New Forest, by F. C. Adams, Esq., was brought about through the Reports of University Institutions which are now sent to members of Convocation. The Rev. Harold T. Adams, M.A., kindly directed the attention of the donor to the section dealing with this Department.

Among the uncatalogued accessions by far the most important are the specimens from Majorca, the Eastern Pyrenees, and Montserrat near Barcelona, collected by Professor Poulton, Mr. W. Holland and Mr. A. H. Hamm, during four weeks in June and July, 1901. An immense amount of labour must be expended upon this collection before it is in a condition to be described and incorporated; but it is confidently anticipated that there will be several new species among the less known orders, and many new and interesting records of the geographical distribution of European species.

Of very great value and importance is the large series of named American moths presented by W. Schaus, Esq., F.Z.S.

Valuable donations have also been made by Herbert Druce, Esq., F.L.S., from many localities; by W. M. Geldart, Esq., M.A., Trinity College, from Greece; by R. Shelford, Esq., M.A., from Borneo; and by W. C. Boyd, Esq., from many British localities.

A very important set of Lepidoptera from China and Thibet, belonging to the collection made by the late J. H. Leech, Esq., was purchased at Stevens'.

The arrangement of the General Collection of *Nymphalinae* has been continued by Mr. Holland, and is now nearly complete. Allowing cabinet space for the *Pierinae* which were being finally arranged by Dr. Dixey and one 20-drawer cabinet for a portion of the material bearing on mimicry, &c., the whole of the consignment of cabinets purchased by the Common University Fund has been occupied by the butterflies of this immense sub-family, and the later groups are still arranged in temporary quarters. The re-setting of the General Collection has made but little progress during 1901, because of the amount of work which has been expended upon recent accessions, especially the vast series of insects of many orders from Borneo, presented by Mr. Shelford.

The *Lycaenidae*, with very few exceptions, have now been named and arranged in their order by Hamilton H. C. J. Druce, Esq. It is a very great comfort to know that the species of this difficult and comparatively little studied family of butterflies are now accurately determined, and I desire to express my grateful thanks to Mr. Druce for his kind help.

The usual visit of the Council of the Entomological Society did not take place, because the expedition to Spain and the Balearic Islands could not be postponed until after the time of meeting, in the beginning of July. The Department has however been visited by many resident and non-resident naturalists, the latter including Mr. W. J. Lucas, Mr. R. Shelford, M.A., of the Sarawak Museum, Mr. C. W. Dale, Mr. W. C. Boyd, Professor C. W. Woodworth, of Berkeley, California, U.S.A., Mr. F. Muir, Mr. C. J. M. Gordon, M.A., Balliol College, of Old Calabar, Professor Meldola, and the Rev. Canon Fowler, M.A., D.Sc., Jesus College, President of the Entomological Society of London.

It is a great pleasure to observe that the Department tends more and more to become a centre for all resident naturalists who are specially interested in insects.

Mr. Pogson Smith, M.A., St. John's College, has continued the identification and arrangement of the British *Tineina*. Dr. F. A. Dixey has done a great deal of valuable work upon the General Collection of *Pierinae*. The large accessions of butterflies of this group, constantly received from many parts of the world, especially the Ethiopian region, have involved much extra labour because of the re-arrangement of the older material which became necessary. As a result of Dr. Dixey's patient researches and remarkable power in using the materials of his investigations as a means for elucidating the problems of evolution and unravelling the tangled threads of phylogeny, the Oxford Collection of *Pierinae* has become one which no serious student of the group can afford to neglect.

I again wish to express my thanks to the members of the staff of the Insect Department of the British Museum of Natural History, who have helped me in the study of many groups.

The chief researches conducted in the Department during 1901 have been concerned with the material presented by Mr. Guy A. K. Marshall and Mr. R. Shelford, and the Balearic insects, collected by Professor Poulton. References to the publications will be found in the parts of the Report dealing with these donations.

ADDITIONS TO THE COLLECTION IN 1898 AND 1899.

The gifts which were uncatalogued at the publication of the last Report remain in the same condition. The delay has been in part due to the hope that further data may be forthcoming, and in part to the advantage of printing the donations of two or three years together in those cases in which the same data are likely to be repeated frequently. The immense labour required by the generous consignments of R. Shelford, Esq., M.A., from Sarawak, Borneo, and by the Siamese butterflies collected by Richard Evans, Esq.,

M.A., D.Sc., Jesus College, also severely taxed the Department. The pinning and setting of the former is now complete and the latter far advanced.

Mr. Shelford's valuable and extensive material bearing on the study of mimicry in Bornean insects presented in 1899 and the two subsequent years illustrates a paper by him which was read before the Zoological Society in January, 1902, and will shortly be published in the Proceedings.

ADDITIONS TO THE COLLECTION IN 1900.

Since the last Report a large number of specimens have been catalogued and incorporated, and are now gratefully acknowledged.

A set of 6 butterflies collected by Lieut.-Col. Manning at Zomba (1899).

A set of 62 butterflies collected by Col. J. B. Yule in Nyassaland (1896).

A set of 36 Lepidoptera collected (1894) in the Arusa Galla Country, Somaliland, by F. Gillett, Esq.

A set of 30 butterflies collected (1898) by A. Ross, Esq., at Johannesburg.

A set of 25 butterflies collected or bred by Rev. W. D. Cowan, in Betsileo, Madagascar.

A specimen of *Linnaea chrysippus* captured (1891) at Fort Dauphin, Madagascar, by the Hon. Reg. Walsh.

Five butterflies from the forests near Antananarivo, Madagascar (date uncertain).

A specimen of *Hypolimnas misippus* collected (1887) by D. W. Barker, Esq., R.N.R., at Massowah.

A specimen of *Linnaea chrysippus* collected by G. Gulliver, Esq., at Rodriguez (1874).

Seven butterflies collected by C. W. Bewsher, Esq., at Johanna Island, Comoro Islands.

The whole of the above-named specimens were duplicates from the collection of the British Museum, kindly presented by the Trustees.

A set of 5 *Locustidae* from the Bay of Antivari, Montenegro (1900), were presented by the captor, Malcolm Burr, Esq., New College.

A male specimen of the moth *O. dispar* from Paris (1900) was presented by the captor, Professor Poulton.

Nine butterflies from the Sandwich Islands were presented by the Trustees of the British Museum, including several specimens of *Vanessa tammeana* captured by R. C. L. Perkins, Esq., in 1895-6. This magnificent ally of our own "Red Admiral" (*Vanessa atalanta*) is new to the Hope Collection.

The splendid accession to the Oriental species in the Collection, which we owe to the generosity of Mrs. W. B. Pryer, has now been almost entirely catalogued and incorporated. Nearly the whole collection was made by the late Mr. W. B. Pryer at the East Coast Residency of British North Borneo between the years 1878 and 1898. 1,043 butterflies from this locality have been incorporated, viz. the whole of the families with the exception of the *Lycænidæ*, which have been very kindly worked out for us by Mr. Hamilton H. C. J. Druce. 92 moths and 7 insects of Orders other than the Lepidoptera from the same locality have also been added to the Collections. There still remain the numerous *Lycænidæ* from the East Coast Residency, and a comparatively few specimens from other places, or from exact localities within the Residency. This important gift, together with the fine series of Bornean butterflies presented by Mr. Herbert Druce in 1899, renders the University collection from this island remarkably fine and complete.

One Asilid (Diptera), and 45 Hymenoptera, comprising 40 Aculeata, 4 *Chrysididæ*, and 1 Ichneumonid, from the neighbourhood of Salisbury, Mashonaland (1899-1900), were captured and presented by R. H. Thomas, Esq.

These Hymenoptera, together with the large collection from the same locality presented by G. A. K. Marshall, Esq., are being kindly worked out by Col. C. T. Bingham.

The following splendid additions to the University Collections are due to the kindness and skill of Guy A. K. Marshall, Esq. The locality, except when otherwise stated, is Salisbury, Mashonaland, and the captor Mr. Marshall.

A fine general collection of Hymenoptera Aculeata, containing 610 specimens. Some of these have been found by Col. Bingham to be new species. Other Hymenoptera: 5 *Chrysididae*, 13 *Chalcididae*, and 3 other *Terebrantia*.

The following Orthoptera: 2 *Forficulidae*, 23 *Blattidae*, 198 *Acridiidae*, 23 *Locustidae*, 6 *Gryllidae*, 47 *Mantidae*, and 1 *Phasmid*. Also 1 Locustid and 1 *Blatta* from the Umfuli district (1899).

The following Rhynchota: 10 Hemiptera and 3 Homoptera.

Thirteen Diptera: 1 *Mantispa* (Neuroptera), 10 Coleoptera.

The following fine additions to the bionomic series, especially the parts illustrating Batesian and Müllerian Mimicry, Fifteen Hemiptera, forming components of various mimetic groups: 2 Reduviids (Hemiptera), a Longicorn and a Cantharid beetle, all dark iridescent blue-black, and resembling an important group of Aculeate Hymenoptera. The wonderful group of insects mimetic of the well-known Ethiopian Lycid beetles, with a tawny colouring anteriorly and black posteriorly, formerly presented by Mr. Marshall, has now been greatly strengthened by 8 beetles, 4 moths, 2 Hemiptera, 3 Ichneumonids, and 2 Aculeate Hymenoptera. Thirty-four specimens are divided between the following groups, the models of which appear always to belong to the stinging Hymenoptera: (1) black insects with yellow or red head and sometimes thorax, and in some species black and yellow legs—Aculeates, Ichneumonids, Hemiptera, beetles, flies; (2) greyish black anteriorly, red-brown posteriorly—Aculeates and an Asilid fly; (3) black with red or yellow apex to abdomen—Aculeates, Bombylid fly; (4) black ant-like group—ants, Coreid and Reduviid Hemiptera.

A small proportion of Mr. Marshall's generous gift, which is here gratefully acknowledged, has been accidentally transferred to the catalogue for 1900 instead of 1901 to which it properly belonged. Hence his donation for the latter year appears smaller than it actually was, and that for the former year larger in the same degree. Inasmuch as the printed locality labels on the specimens remain strictly accurate and contain a statement of the correct date of pre-

sensation, it was not thought necessary to undertake the considerable labour of altering the catalogue and the small label on the specimens which record the catalogue number and year.

A fine collection of 419 insects of all Orders from British Central Africa was presented by C. V. A. Peel, Esq. The insects were collected in 1899 by C. H. Pemberton, Esq., over a very extensive tract of interesting country to the W. of Lake Nyassa, from Kota-Kota on the shore of the Lake to the Loangwa River Valley, the Mushinga Mountains and Chitala. The numerous localities and dates are accurately recorded. The collection is especially valuable, inasmuch as the Hope Museum possesses very little material from this part of Africa.

A small collection of 36 Lepidoptera made by the same naturalist at Delagoa Bay on Aug. 10, 1899, and a Mantid captured by him on the Lower Zambesi in July of the same year, were also presented by C. V. A. Peel, Esq.

A set of 55 insects of various Orders, and 10 other Arthropoda from different localities in Cape Colony, were captured (1899-1900) and presented by E. N. Bennett, Esq., M.A., Hertford College. Although the species are apparently not rare the localities render them of much interest and value to the Hope Collection.

The collection of insects of many Orders from Majorca and Menorca captured in March and April, 1900, has now been catalogued, and some of the groups worked out and lists published. This collection, together with the much larger one made in 1901, constitutes by far the most important addition to our European collection during recent years. The following is an account of the 1900 captures.

Five hundred and ninety-eight specimens were captured and presented by Professor Poulton. The great majority of these are from Majorca (many localities), a relatively few from Menorca (Mahon). A list of the Diptera has been published by Col. J. W. Yerbury (Ent. M. Mag., 1890, p. 272), the species of principal interest being *Phoranthia subcolepstrata* and *Bombylius pictus*. The Hymenoptera *Aculeata* have been described by Edward Saunders, Esq., F.R.S. (l.c., p. 208). Forty-eight species were obtained, two of which are

new to science, viz. a fine bee of the parasitic genus *Nomada* described as *N. poultoni* (Saunders), and a new *Halictus*, *H. soror* (Saunders). Of the latter 2 females were obtained (Castle Bellver, Palma, March 26 and 30); of the former 1 male and 3 females (Castle Bellver, 400 ft., on flowers, 1 female March 25, the others March 30). The common British Humble-bee, *Bombus terrestris*, was very abundant on flowers; but all the specimens were of the variety *ferrugineus*, from SW. France, Spain, and Portugal, which differs from the type in having the hairs of the tibiae fulvous instead of black. Of the Hemiptera 14 species were obtained, and a list has been published by Mr. Saunders (l. c., pp. 239, 240), who points out that all the specimens of *Lygacus pandurus*, very abundant in Majorca, are of the variety with milky-white unspotted membrane, like those from Algeria.

Twenty-eight insects and arachnids from the same localities were captured and presented by E. S. Goodrich, Esq., M.A., Merton College, and 17 Coleoptera by Mr. Goodrich and Professor Poulton. Of the latter, 15 were captured in Menorca, where beetles were much more abundant than in the larger island, at the time of our visit.

A valuable set of Coleoptera and a few other insects from the neighbourhood of Mahon were captured and presented by Señ. Mauricio Hernandez. They include 42 Coleoptera captured about 1885, together with 27 insects of various Orders captured in 1900. The few Hymenoptera Aculeata are included in the Mr. Saunders's published list alluded to above.

Forty-one Coleoptera and one Hemipteron were captured (April 6, 1900) near Mahon, and presented by Mr. Goodrich, Señ. Hernandez, and Professor Poulton.

Forty-three insects of various Orders from the neighbourhood of Barcelona and Montserrat (about 3,000 ft.) were captured in March, 1900, and presented by Professor Poulton, and 6 insects from the same localities by E. S. Goodrich, Esq., while 6 from Barcelona were captured and presented by these two naturalists jointly. Specimens from this part of Spain have hitherto been wanting in the Hope Collection, and are rare in European collections generally.

Two specimens of *Deudorix antalus* from Manashi, near Cairo, were presented by E. A. Floyer, Esq. The larvae had been injurious to "*Iuga dulcis*," feeding upon the seed-pods. The specimens were kindly transmitted by Professor Wyndham R. Dunstan, F.R.S.

Seven specimens of *Aporia crataegi* were bred from pupae (Germany, 1900) presented by F. Merrifield, Esq.

A pair of the Aculeate, *Prosopis variegatus*, and of the fly (*Paragus bicolor*) which mimic it, were presented by Edward Saunders, Esq., F.R.S. The specimens were from Algeria (1896), Italy (1895), and Brittany (1900). The interesting resemblance of the facial markings of the male fly to those of the male bee, and the facial markings of the female fly to those of the female bee has been described by Mr. Saunders (Ent. Monthly Mag. 1900, p. 83).

The following kind donations, mentioned in the Report of last year, are still uncatalogued. The Bornean insects of R. Shelford, Esq., M.A.; the moths from many localities, and other insects of Herbert Druce, Esq., F.L.S.; the Lepidoptera from the Khasias, Borneo and Mexico, of G. C. Griffiths, Esq.; the insects from Iceland and the Faröes of N. Annandale, Esq., B.A., Balliol College; the South African and Eastern European insects (in addition to those from Montenegro, catalogued above) of Malcolm Burr, Esq., New College; the Javan dragon-flies of R. McLachlan, Esq., F.R.S.; the Oriental butterflies of Mr. W. Holland; the Bornean moths of Col. Swinhoe, Hon. M.A., Wadham College; the Swiss butterflies of H. M. Wallis, Esq. and A. Wallis, Esq.; the American Coleoptera of R. d'A. Morrell, Esq.; the Oriental Coleoptera of F. W. Andrewes, Esq., D.M., Christ Church, and H. E. Andrewes, Esq.; and a large proportion of the duplicate butterflies presented by the Trustees of the British Museum of Natural History.

The specimens purchased from Sign. M. A. de Bormans and Messrs. Watkins and Doncaster are also uncatalogued.

The catalogue of British insects presented in 1900 has now been completed, and the specimens incorporated in the collection. The gifts which were not catalogued at the appearance of the last annual Report are acknowledged below.

A specimen of *Plusia moneta*, captured on honeysuckle at Pyrton (1900), was presented by Rev. J. W. B. Bell. This interesting moth, which was unknown in this country not many years ago, has been hitherto unrepresented in our British Collection.

A beetle, *Balaninus glandium*, from near Bladon (1900) was presented by Miss C. A. Brown, and *Hedobia imperialis* from Oxford (1900) by J. E. Pogson Smith.

A bred specimen of the moth *Anarta myrtilli*, together with its cocoon and pupa-case, from Dartmoor (1899), was presented by H. E. Butler, Esq.

A Dipteron from Oxford (1900) was presented by Dr. W. H. Jackson, of Keble College.

A specimen of *Polyommatus corydon* from Boar's Hill (Sept. 12, 1900) was presented by H. St. G. Gray, Esq., together with *C. edusa* and *N. lucina* from Dorset and Wiltshire. The former capture is of great interest, for the "Chalk-hill Blue" has never before, so far as I am aware, been observed so near to Oxford.

An interesting series of 8 *Smerinthus populi* were bred in the Hope Department (June-July, 1900). In the excessive heat of the latter month in 1900, the moths appeared in a week or two after pupation, instead of emerging in June, 1901, after a pupal period of normal length. All the specimens are of an unusual shade of colour, a probable result of the high temperature.

Four moths and a dipterous insect were captured in Yorkshire (1900), and presented by Professor Poulton and E. P. Poulton, Esq.; a remarkably small worker wasp (*Vespa vulgaris*), from St. Helens, Isle of Wight (1900), was presented by Ronald W. Poulton.

Sixty-nine insects of several Orders from the neighbourhood of St. Helens, Isle of Wight, and 18 from various localities in and near Oxford, were captured (1900) and presented by Professor Poulton.

A pair of *Vanessa urticae* ("The Small Tortoise-shell Butterfly"), captured in the meadows by the Cherwell at Oxford (May, 1900), was presented by Professor Poulton.

The later stages of courtship were observed in these specimens, for the first time in the case of this common species. The notes will be recorded.

Twenty-two insects of different Orders from the neighbourhood of Oxford (1900) and 11 moths from near Reading (1891) and Basingstoke (1892) were captured and presented by Mr. W. Holland.

A very useful set of 115 insects of different Orders from Mundesley, Norfolk, was captured (1900) and presented by Mr. W. Holland. The series includes a fine series of the varieties of the moth *Zygaena trifolii*. Mr. Holland also captured in the same locality and presented 62 insects belonging to the Hymenoptera, Diptera and Coleoptera. These insects consist of three groups, each captured in a single day, and in one place. The species in each group thus found together exhibit more or less marked similarity in colour and pattern, and will be kept together in the bionomic series.

A specimen of the Pentatomid bug, *Aethus flavicornis* (Fab.), was presented by Mr. W. Holland, who captured it at Freshwater, Isle of Wight, in July, 1895. The specimen is of great interest, having been identified and recorded by Mr. Edward Saunders as "a genus and species new to the list of British Hemiptera" (*Entomologists' Monthly Magazine*, 1899, p. 155).

One hundred and thirty insects of different Orders from various localities in and near Oxford were captured (1900) and presented by Mr. A. H. Hamm. They include Aculeate Hymenoptera with their dipterous foes, and sets of insects of very different kinds, with a similar appearance, taken together at the same place and time. Four specimens of a butterfly new to the Oxford district, *Thecla W. album* ("The White Letter Hairstreak"), from Tubney, are also included, together with 3 *Colias hyale* ("Pale Clouded Yellow") from Cowley Marsh.

Another set of 54 insects from the neighbourhood of Oxford and S. Devon was presented by Mr. A. H. Hamm, having been captured or bred by him in 1900. They include a fine series of bred *Callimorpha hera* ("The Jersey Tiger") from Dawlish, a moth probably introduced into this

country and now steadily extending its range; and 7 specimens of *Pyrrhosoma tenellum*, from Newton Abbot, a dragon-fly new to our British Collection. Many of the specimens illustrate the biological relations between insects and their enemies, and will be added to the Bionomic Series.

Mr. Hamm also presented an interesting set of 6 cocoons of the moth *C. neustria* (Oxford, 1900), 5 of which had been opened by birds and the pupae abstracted, while one had produced a parasitic insect: for the Bionomic Series.

Colonel Yerbury's donation of Scotch and English Diptera and Hymenoptera were erroneously catalogued as presented in 1901 (see p. 20).

The 5 specimens of *Acherontia atropos*, bred from larvae from the Oxford district, presented by Mr. Austin, Mr. W. H. Greenaway, Mr. F. Lewis, Mr. R. Jones, and Miss Churchill, together with the specimen of the perfect insect presented by Mr. G. Hunt, are now catalogued and incorporated. The two pupae presented by Mr. N. Brett failed to produce moths.

Two specimens of *Papilio machaon* were bred from pupae from Wicken Fen (1899), presented by F. Merrifield, Esq.

Four *Vanessa polychloros* were bred from larvae from West Sussex (1900), presented by Miss Cora B. Sanders.

A specimen of the rare moth *Bombyx trifolii*, from St. Helens, Isle of Wight (1900), was presented by Mrs. Gotch.

A specimen of the very rare butterfly *Picris daplidice* (the "Bath White"), with the locality Ascot (1897), was presented by H. A. Ormerod, Esq.

A specimen of *Agrotis praeceox*, captured at "sugar" at St. Helens, Isle of Wight (1900), was presented by E. P. Poulton, Esq.

Interesting examples of a British beetle (*Polydesmus undatus*) protectively resembling parts of the birch (Tilgate Forest, 1891), and of *Creptodera transversa* resembling the seeds swept with them (Oulton Broad, 1900), were presented by H. Donisthorpe, Esq., together with a specimen of *Cassida equestris* (Wicken Fen, 1900) with injuries probably caused

by the attacks of enemies. This material is a welcome addition to the rapidly growing Bionomic Series.

A set of ants, and the immature Hemiptera which mimic them, were presented by Mr. A. H. Hamm. The insects were captured together on the bark of an apple-tree at Oxford (1900).

Six specimens of the beetle *Niptus hololeucus*, from Oxford (1900), were presented by Dr. Stark; and 7 of the same species, from Shropshire (1900), by W. P. D. Stebbing, Esq. The latter were found in decayed *pot pourri* fifty years old.

Twenty-nine insects of various Orders from Oxford and various other English localities (1900) were captured and presented by Dr. F. A. Dixey. Twenty insects of various Orders from the neighbourhood of Totland Bay, Isle of Wight (1900), were captured and presented by Giles Dixey. Excellent data accompany both these sets of insects.

Seventy-five specimens of the interesting northern variety, *hethlandica*, of the "Ghost Swift," *Hepialus humuli*, from Unst, Shetland, were purchased (1900) at Stevens's sale. Eight specimens are added to the General Collection.

ADDITIONS TO THE COLLECTION IN 1901.

A valuable set of 113 Lepidoptera from Trinidad (about 1874) were presented by Professor R. Meldola, F.R.S.

Three specimens of a rare Satyrine butterfly (*Leptoncurea borekeri*) from Natal (1901) were presented by Colonel Swinhoe, Hon. M.A., Wadham College.

A small but valuable set of 75 Lepidoptera, 1 Cicada, and 1 Longicorn beetle, from Southern Nigeria, were captured (1900-1901) and presented by C. J. M. Gordon, Esq., M.A., of Balliol College. The exact locality of capture was the stretch of thirty miles intervening between the Forcados mouth of the Niger and Warri, a most interesting district, and one hitherto unrepresented in the Hope Collection. Among the butterflies an Erycinid and all the *Lycanidae* were especially wanted, together with some very interesting mimetic specimens.

A valuable set of 77 butterflies from Southern Spain (Algerias, Cordova, Granada, Malaga, Gibraltar) were captured (1901) and presented by Col. J. W. Yerbury. The excellent condition of the specimens and the full data accompanying them render the gift most acceptable. The specimens of the Pierine, *Zegris eupheme*, with full data, were specially wanted.

Col. Yerbury also presented a pair of the Bombus-like fly, *Mallota fuciformis*, captured by him at Hyères (1898), and a pair of the wasp-like fly, *Ceria eumenoides*, captured at Matheran, Bombay (1879), by Major C. G. Nurse: for the Mimicry Series.

Material of inestimable value from Rhodesia, illustrating seasonable changes and their causes, mimicry, &c., was presented by Guy A. K. Marshall, Esq., together with a fine series of specimens for the General Collection. Unless otherwise mentioned, the specimens were captured or bred at Salisbury, Mashonaland, in 1901.

Twenty-five specimens of the Pierine genus *Terias* include the results of many experiments in which Mr. Marshall attempted to reproduce the wet season form by placing the larva and pupa or the pupa alone in a damp atmosphere. The species experimented on were *T. senegalensis*, *T. regularis*, and *T. brigitta*. The results have been recorded and discussed by Mr. Marshall (Ann. and Mag. Nat. Hist., 1901, vol. ii, p. 398), and by Dr. Dixey (Trans. Ent. Soc. Lond., 1902, p. 189).

Fifteen specimens of the two species of the Nymphaline genus *Byblia*, *B. ilithyia* and *B. achcloia*, included 4 captured females and offspring reared from eggs laid by each of them; thus demonstrating the parallel seasonal alternation in pattern and colouring of the under side of the wings in both species. The results of these investigations, which in certain cases included the use of a damp atmosphere, have been recorded and discussed in the papers already referred to by Mr. G. A. K. Marshall and Dr. F. A. Dixey.

Three specimens of the Nymphaline butterfly *Precis archesia* had been subjected in the pupal state to a moist atmosphere. The forms were nevertheless those which are characteristic of the dry season, apparently indicating that

the change is not in this species due to the direct influence of environmental conditions. This result has also been recorded by Mr. Marshall (l. c.).

Nineteen butterflies showing injuries to the wings, probably caused by the attacks of enemies.

Five butterflies captured on the same day, Sept. 28, 1900, including 3 similar species of *Acraea* and 1 Lycaenid with an *Acraea*-like under side.

The Lycaenid *Alacna nyassa* and the Hesperid *Cyclopides willemi* with a somewhat similar under side, captured on the same day, Feb. 23, 1901; and a similar pair captured March 3, 1901.

A dark-winged fly and Zygaenid moth (Dec., 1900), mimetic of the large group of black dark-winged Aculeate Hymenoptera.

Three Ichneumonids and 2 Longicorns (1900, 1901) form part of an interesting group of black insects with the anterior parts of an ochreous or reddish colour. An Aculeate and a sesiid moth (1900), with the same general type of colouring, afford beautiful examples of model and mimic. Four Ichneumonids (1900) constitute a very characteristically coloured group of black-barred ochreous insects mimicked in the most perfect manner by a Reduviid bug of a new species. Two other Reduviids entered respectively the large group of which the models are many species of black Aculeates, and the characteristic group formed round the Lycid beetles.

A beautiful group of 4 black Aculeates with yellow- or orange-tipped abdomen from Umtali, Mashonaland (1900), are beautifully mimicked by a sesiid moth from the same locality: 2 specimens of the latter were presented. Three specimens of *Acraea encedon*, 2 of a Lycaenid (*Catochrysops peculiaris*), and 2 of a rare Hesperid (*Abantis tettensis*), all from Umtali (1900). The two latter species show probable incipient mimicry of the Acraeinae type.

A most interesting group of insects was captured together on a plant at Salisbury on Feb. 17, 1901. Four specimens of black ants were the models mimicked by a Locustid, *Myrme-*

cophana sp., and 2 specimens of a Coreid bug of a new genus and species to be described by Mr. W. L. Distant in Mr. Marshall's forthcoming paper describing the whole of his material which bears on mimicry and allied questions.

Two specimens of a dark Ichneumonid with a transparent area in the opaque fore-wings. This species may be the model of a Mashonaland Bombylid fly with a somewhat similar character.

A specimen of an Asilid fly, with its prey a Lycaenid butterfly (1900). Another Asilid, caught (1901) in the act of devouring a dragon-fly far larger than itself.

The General Collection has also been further enriched by Mr. Marshall's great generosity.

Fifty-nine butterflies (Salisbury, 1901) include several interesting and valuable additions to our series of the genus *Precis*, with the exact data which is so especially necessary in studying their seasonal forms. The rare Hesperid *Baoris netopha* is represented by 3 examples. Eleven other insects include a male specimen of the rare mosquito discovered by Mr. Marshall, *Megarrhina marshalli*.

Thirty-five insects from Umtali, Mashonaland, 3,700 ft. (1900), include further valuable additions to the genus *Precis*, and several rare *Hesperidae*, &c.

Mr. Marshall also presented the following insects not of his own capture:—Three moths from Beira (1900), 2 insects from Umtali (1900), and a pair of the Danaine butterfly *Limnas chrysippus*, var. *klugii*, from Dar-es-Salaam, German East Africa (1899).

A fine series of 7 specimens of the beautiful Morphine butterfly *Zeuxidia horsfieldii*, and 10 specimens of *Z. amethystus* from Sandakan, Borneo (1895-6), were presented by Herbert Druce, Esq., F.L.S., together with a set of 7 *Limnas chrysippus* and 1 *Argynnis lathonia* from Tenerife, and a large number of insects as yet uncatalogued.

Fifty-two insects of many Orders, and 3 spiders from Madeira, were captured (Dec. 1900-Jan. 1901) and presented by E. S. Goodrich, Esq., M.A., Merton College.

Two hundred and forty-five Lepidoptera collected (1848-57) almost, if not entirely, in the neighbourhood of Bogota,

Columbia, by the late Edward W. Mark, Esq., II. M. Vice-Consul, were presented by F. W. Mark, Esq. Eight of the specimens are moths, and the remainder butterflies. All are much wanted in the University Collection, several species being entirely unrepresented. Considering the date of capture and the fact that no special technical skill has been employed in preventing deterioration for so long a period, the condition of the majority of the specimens is remarkably good. I desire to thank E. J. Trevelyan, Esq., M.A., B.C.L., All Souls College, and Mrs. Trevelyan, for rendering generous assistance to the University Collections by bringing the matter to the attention of the kind donor.

A large number of insects other than Lepidoptera, with the same history as the above, were also presented by F. W. Mark, Esq. These are as yet uncatalogued.

A valuable set of 80 insects of various Orders, and 1 Arachnid from near Laurier, Manitoba, Canada, were presented by Miss Mary G. Holmes. The data are most precise and detailed, and the specimens a most useful addition to our Canadian series.

Two specimens of the extremely local *Erebia arete* were captured (July, 1877) at Stelzing, Carinthia, and presented by R. W. Lloyd, Esq., and another specimen from the same locality by W. E. Nicholson, Esq.

A series of 88 butterflies, collected (1885-1891) at various localities in Burmah by the late Captain E. Y. Watson, was presented by the Trustees of the British Museum, together with a specimen of *Limnitis calidava* captured (1892) in Ceylon by Col. J. W. Yerbury. The data accompanying all these specimens are precise and detailed. The additions to our collection of Oriental *Danaina* and *Euplocina* are especially useful.

Twenty-seven butterflies and 1 moth from Tobago (date unknown), and 36 Lepidoptera from the neighbourhood of Brisbane (1897-99), were presented by G. C. Griffiths, Esq.

Eleven insects from the Klondyke area (1901) were presented by Professor H. A. Miers, M.A., D.Sc., F.R.S., Magdalen College. Although the specimens are very interesting from the point of view of locality, they appear to belong chiefly, if not entirely, to well-known North American species.

Eighty-three butterflies from near Kaka and Gharb-el-Aish on the White Nile (1901) were presented by the captor, W. L. S. Loat, Esq. The locality (between 10 and 11 N. Lat.) renders the specimens of great interest. An account of this consignment, together with another from the more southern reaches of the White Nile, kindly sent by Mr. Loat during the present year, will be published by Dr. F. A. Dixey. I desire to thank A. E. Tutton, Esq., B.Sc., F.R.S., for kindly calling the attention of the donor of these specimens to the needs of the Hope Department. The data accompanying the specimens are admirably complete, and greatly enhance their value.

A valuable set of 262 insects of various Orders from Kitui, British East Africa (1901), was presented by the captors, S. L. Hinde, Esq., and Mrs. Hinde. The butterflies of the Nymphaline genera, *Præcis*, *Neptidopsis*, and *Charaxes*, together with the *Acracinae*, are specially valuable to the Collection, but the whole of the species are most acceptable on account of the excellent data which accompany them.

Nineteen Lepidoptera from Machakos (1901) were also presented by the same kind donors, and these also are a very useful addition to our tropical East African Collection.

Two hundred and eight Lepidoptera from various interesting British East African localities, especially Lomogo, N'Gongo Bagas River (1898-1900), together with 17 Lepidoptera from Mombasa (1900), were also presented by S. L. Hinde, Esq., and Mrs. Hinde. All the specimens were much wanted on account of locality and the accurate data, and many of them are unrepresented or barely represented in the Collection. I may specially mention a fine series of *Synchlœa johnstonii*, three specimens of *Mylothris rubricosta*, and the very interesting series of the different forms of *Linnaea chrysippus*, and of its chief mimic the female of *Hypolimnna misippus*.

A specimen of a Mylabrid beetle from Sierra Leone (1858), with the head of a Termite fixed to one of its legs, was received in exchange from the British Museum.

The purchased Chinese and Thibetan Lepidoptera are not catalogued.

The following donations are as yet uncatalogued :—the numerous specimens from Majorca and Spain, by Professor Poulton, Mr. Holland, and Mr. Hamm ; many specimens, especially Lepidoptera, from various localities, by Herbert Druce, Esq., F.L.S. ; insects of many Orders from Borneo, by R. Shelford, Esq., M.A. ; Grecian butterflies, by W. M. Geldart, Esq., M.A. ; a valuable and very numerous series of named American moths, presented by W. Schaus, Esq., F.Z.S. ; a set of butterflies from the Italian Riviera, by Hugh Richardson, Esq., and from Germany by E. L. Meyer, Esq. ; an immature Mantid from British Bechuanaland, and a spider introduced in bananas, by H. Ward, Esq. ; a set of insects of various Orders from Germany and Denmark, by Professor Poulton ; *Forficulidae* from Japan, by Harold Hornsey ; a *Blatta* from Jamaica, by Mr. E. Wheal ; a specimen of *Melitaea artemis* from Italy, by Miss Butler ; specimens from Norway, by Colonel Swinhoe and by E. N. Bennett, Esq., M.A. ; from Europe, by H. M. Wallis, Esq. ; from Topeka, Kansas, by C. L. Pribble, Esq.

The following additions to our British Collections in 1901 have been catalogued and incorporated :

A magnificent specimen of *Vanessa antiopa* ("The Camberwell Beauty") was presented by the Rev. J. W. B. Bell, M.A. The butterfly was captured, August 19, 1900, by Mr. Bell, at rest on a post which had been "sugared" for moths, in the Rectory Gardens, Pyrton, Oxon. The capture is recorded in "The Entomologist" for 1900, p. 250. The specimen is of the highest interest and value to the Department, having been taken nearer to Oxford than any other specimen in the University Collection, and also because of its perfectly fresh condition. It is most improbable that such an insect could have emerged from the pupa at any great distance from Pyrton.

Six specimens of the Noctuid moth *Nonagria geminipuncta*, bred (1901) from pupae in reeds found (August, 1901) at Bournemouth, were presented by Major R. B. Robertson.

Colonel J. W. Yerbury presented 9 specimens of Hymenoptera Aculeata and mimetic Diptera, captured (1901) in various localities in Co. Kerry. These are the first examples of mimicry from Ireland in the Hope Collection. Colonel

Yerbury also presented 17 examples of models and mimics from the same Orders captured (1900) in Inverness, Cromarty, and Sutherland; also a pair of the mimetic fly *Gasterophilus equi* from Aldeburgh (1900), and 2 worker bees captured on May 24, 1901, at Belvedere, near Woolwich, together with a pair of the fly *Stratiomys longicornis* which superficially resembles them. All the specimens were captured by Colonel Yerbury, and bear precise statements of locality and date.

This gift constitutes a most valuable addition to our Special Collection of the British illustrations of mimicry.

A fine collection of 378 Diptera from the Lyndhurst district of the New Forest was presented by F. C. Adams, Esq. All the specimens were captured (1900, 1901) by Mr. Adams, and bear exact dates. The condition of the specimens and their beautiful setting are such as to render the gift a most acceptable addition to our poor collection of British Diptera, in which the old specimens are mostly in a bad state, and almost invariably without data.

One hundred and fourteen British butterflies from exact localities in Hampshire, North Devon, Herts, Berks., Oxon., Bucks, Suffolk, Kent, and Sussex, and from Finchley, N., and St. Helens, Isle of Wight, were presented by Dr. F. A. Dixey, Wadham College. The data accompanying the specimens are most precise and accurate; the dates of capture range from 1873 to 1901. The great majority of the specimens were captured by Dr. Dixey, but some were taken by members of his family and friends including Dr. G. B. Longstaff, New College. The gift will be of much value to the University Collection of British insects, a most important section of the Department in great need of assistance.

Twelve equally valuable specimens of British Satyrine butterflies from Berks. and North Devon were captured (1877-1901) and presented to the General Collection by Dr. Dixey.

A set of 8 males and 53 females of the Chalcid parasite *Pteromalus puparum* were presented by Professor Poulton together with the pupa of *Vanessa atalanta*, in which the parent had been seen laying its eggs (Sept. 7-8, 1900). The parasitic Hymenoptera emerged on May 22, 1901.

A valuable set of 43 Lepidoptera captured (1899) by Mr. William Reid, in Perthshire, was presented by G. C. Griffiths, Esq., together with a series of 6 *Limenitis sybilla* and 4 *Tephrosia crepuscularia* from the New Forest (1900). Two specimens of the former are added to the General Collection.

British insects as yet uncatalogued were also presented by Rev. G. B. Simeon, Miss Cora B. Sanders, Major R. B. Robertson, B. Tomlin, Esq., Mr. Mullis, II. Donisthorpe, Esq., W. E. Sharpe, Esq., W. G. Pogson Smith, Esq., C. J. Bayzand, Esq., W. J. Lucas, Esq., H. Thompson, Esq., Mr. W. Alder, Mr. T. Baines, Mr. W. D. Rowles, Mr. H. Trim, Mr. A. Robinson, Mr. W. Holland, Mr. A. H. Hamm, as well as by Professor Poulton and the members of his family. A very important and valuable set of Lepidoptera from many British localities was presented by W. C. Boyd, Esq.

ADDITIONS TO THE HOPE LIBRARY IN 1901.

The Trustees of the British Museum presented the "Catalogue of the Lepidoptera Phalaenac," vol. iii (*Arctiadae* and *Agaristidae*), by Sir George F. Hampson.

The Smithsonian Institution (United States National Museum, Washington) presented the publications which deal with the subjects of the Department, including valuable memoirs by Nathan Banks, Esq. (2 papers), Miss Harriet Richardson, D. W. Coquillett, Esq. (3 papers), James E. Benedict, Esq., Jerome McNeill, Esq., and Ralph V. Chamberlin, Esq.

The Boston Society of Natural History and the Bombay Natural History Society presented their publications for the year 1901.

The United States Department of Agriculture presented a memoir by F. E. L. Beal, Esq., B.S., on the food of certain N. American birds.

Reports of the following Museums, Libraries, and Natural History Societies have been presented to the Hope Department during the year 1901:—

R. Accademia delle Scienze dell' Instituto di Bologna (Transactions, vols. vii and viii; Proceedings, vols. ii (1897-8), iii (1898-9), and iv (1899-1900)).

The Sarawak Museum.

The Bristol Museum and Reference Library.

The Kansas Academy of Science.

The Radcliffe Library, Oxford University Museum.

The Public Museum of the City of Milwaukee.

The Ashmolean Natural History Society of Oxfordshire.

The University Museum of Zoology, Cambridge ("A Revision of the Coleopterous Family Erotylidae").

The Yorkshire College, Leeds.

The Annual "Report of Injurious Insects" for 1900 was presented by the late Miss Eleanor A. Ormerod, LL.D., F.R.Met.Soc.

Parts I and II of the "Monograph of the Membracidae" were presented by B. Buckton, Esq., F.R.S., F.L.S.

Dr. Samuel H. Scudder presented his "Index to N. American Orthoptera" together with 4 papers dealing with the same Order of insects.

"Zoological gleanings from the Royal Indian Marine Survey Ship 'Investigator'" (1901) was presented by the Superintendent of the Indian Museum, Calcutta.

Baron C. R. Osten Sacken presented 5 memoirs upon the Diptera, including "An Introduction to the Record of my Life Work in Entomology."

Seven papers upon American Lepidoptera were presented by W. Schaus, Esq., F.Z.S.

Four papers on Lepidoptera were presented by Herbert Druce, Esq., F.L.S.

Four papers on Australian Crustacea were presented by O. A. Sayce, Esq.

Five papers on Lepidoptera were presented by Dr. Arthur G. Butler, Ph.D., F.L.S., F.Z.S., together with a set of corrected proof-sheets of his "Illustrations of typical specimens of Lepidoptera Heterocera in the collection of the British Museum" (1886) and many plates and coloured drawings of Lepidoptera.

A valuable series of 15 papers on the economic entomology and vegetable pathology of Australia, from the "Queensland Agricultural Journal," were presented by the author, Henry Tryon, Esq.

"A monograph of *Charaxes*, &c." was presented by the authors, the Hon. Walter Rothschild, Ph.D., and Dr. Karl Jordan, Ph.D.

The Transactions of the Entomological Society, and the Transactions and Journal of the Linnean Society for the year 1901, were presented by Professor Poulton.

Copies of original papers on the Arthropoda have been presented by the following authors:—George H. F. Nuttall, Esq., M.A., D.M., Ph.D., and Arthur E. Shipley, Esq., M.A. (1 paper); W. L. Distant, Esq. (2 papers); Gilbert J. Arrow, Esq., F.E.S. (3 papers); Miss Nelly Evans (1 paper); G. C. Bignell, Esq., F.E.S. (1 paper); R. Shelford, Esq., M.A. (1 paper); F. A. Dixey, Esq., D.M. (1 paper, by G. B. Longstaff, Esq., D.M., F.R.C.P.).

The parts of Barrett's "British Lepidoptera," the Ray Society volume and the volume of the Zoological Record for the year 1901, and the Supplementary Catalogue of the Library of the Entomological Society of London, were purchased for the Department.

EDWARD B. POULTON.

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